MECHANICAL ENGINEERING

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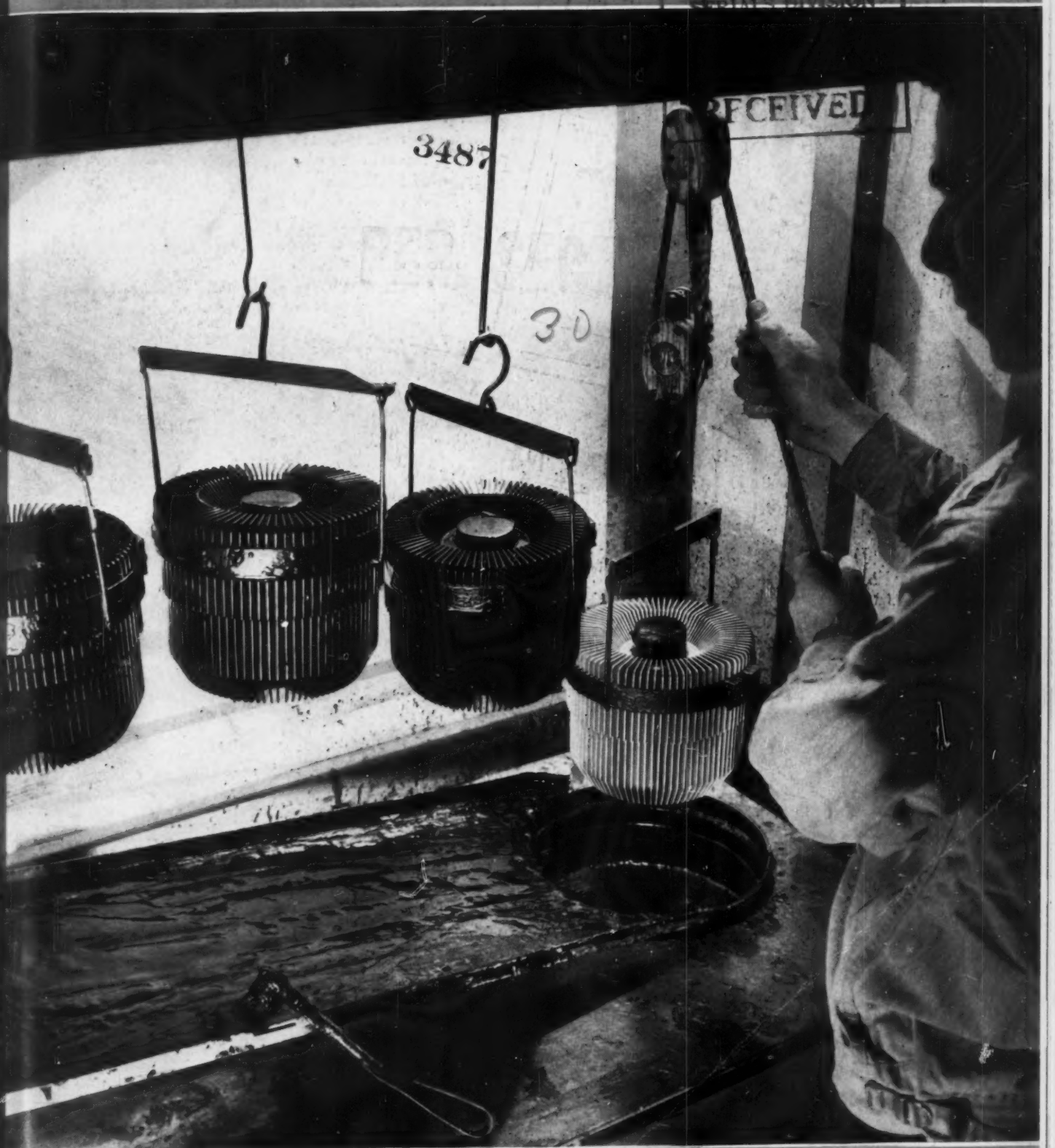

JUNE 1947

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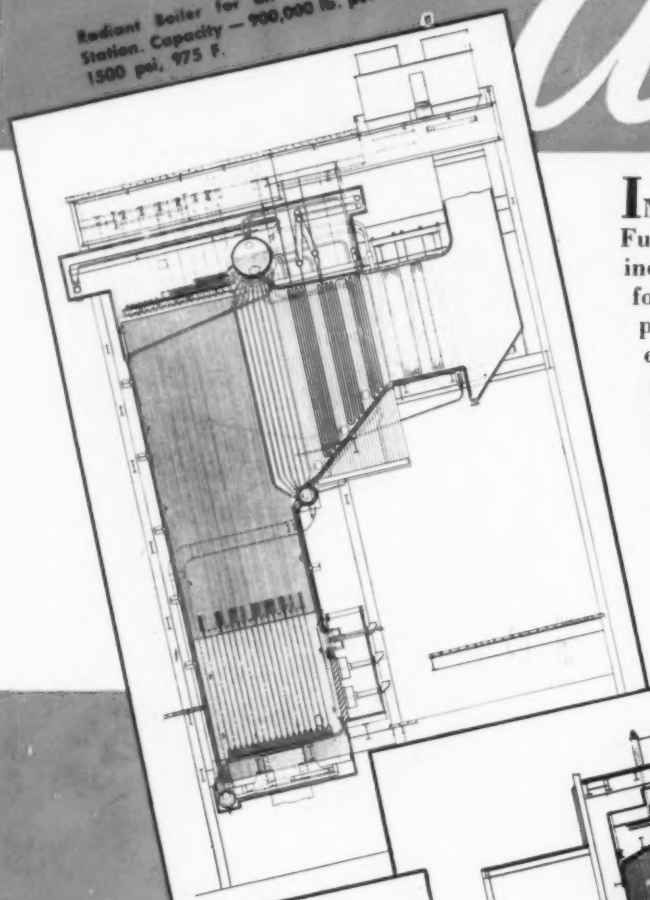
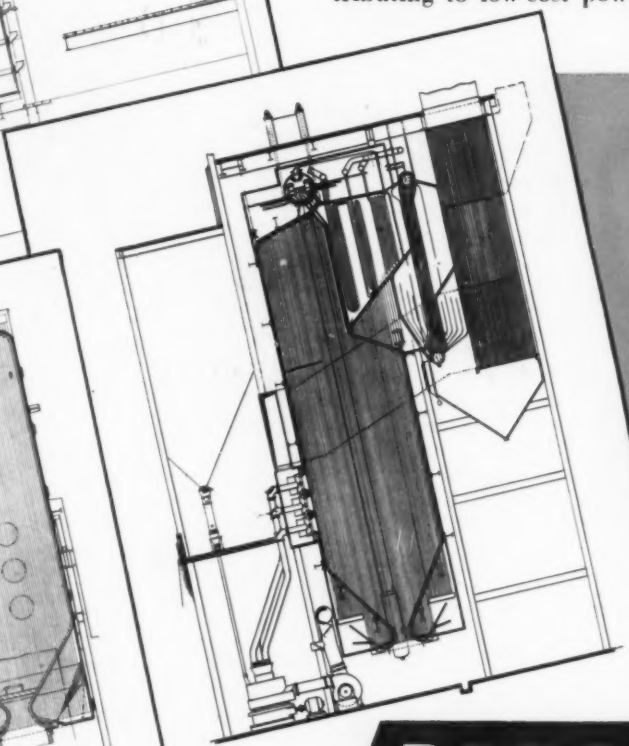
...are MATCHED TO MODERN NEEDS



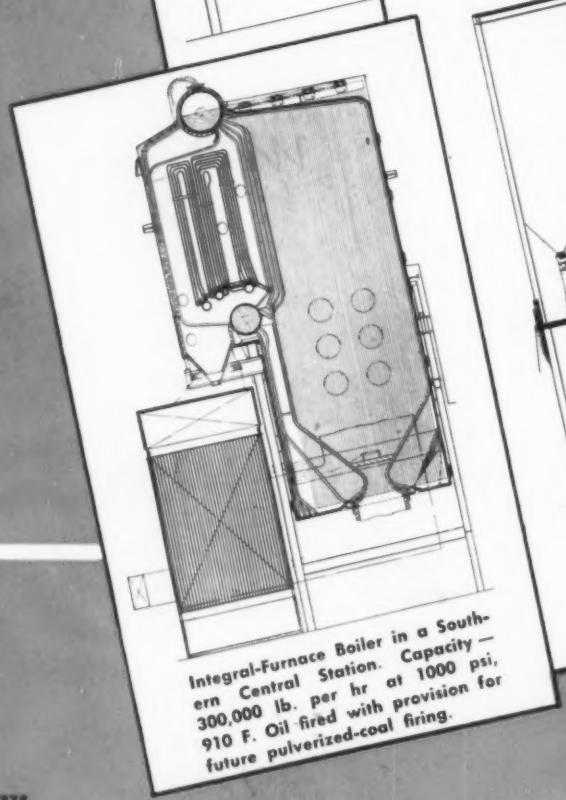
Radiant Boiler for an Eastern Central Station. Capacity — 900,000 lb. per hr at 1500 psi, 975 F.

IN modern Open-Pass, Radiant, Stirling, and Integral-Furnace Boilers, B&W is providing the central-station industry with time-tested, performance-proved designs for low-cost steam generation over the entire range of present-day requirements. Long, satisfactory experience with these types reflects their high standards of performance as to continuity of service, dependability, overall operating efficiency, adaptability to all types of fuels, and greatest return on investment.

B&W experience in matching boilers to jobs for utmost efficiency and economy covers more than seventy years. Such experience cannot be written into specifications or shown on blueprints but it is a part of all modern B&W boilers that is contributing to low-cost power production.



Radiant Boiler in a Mid-Western Central Station. Capacity—600,000 lb. per hr. at 925 psi, 900 F.



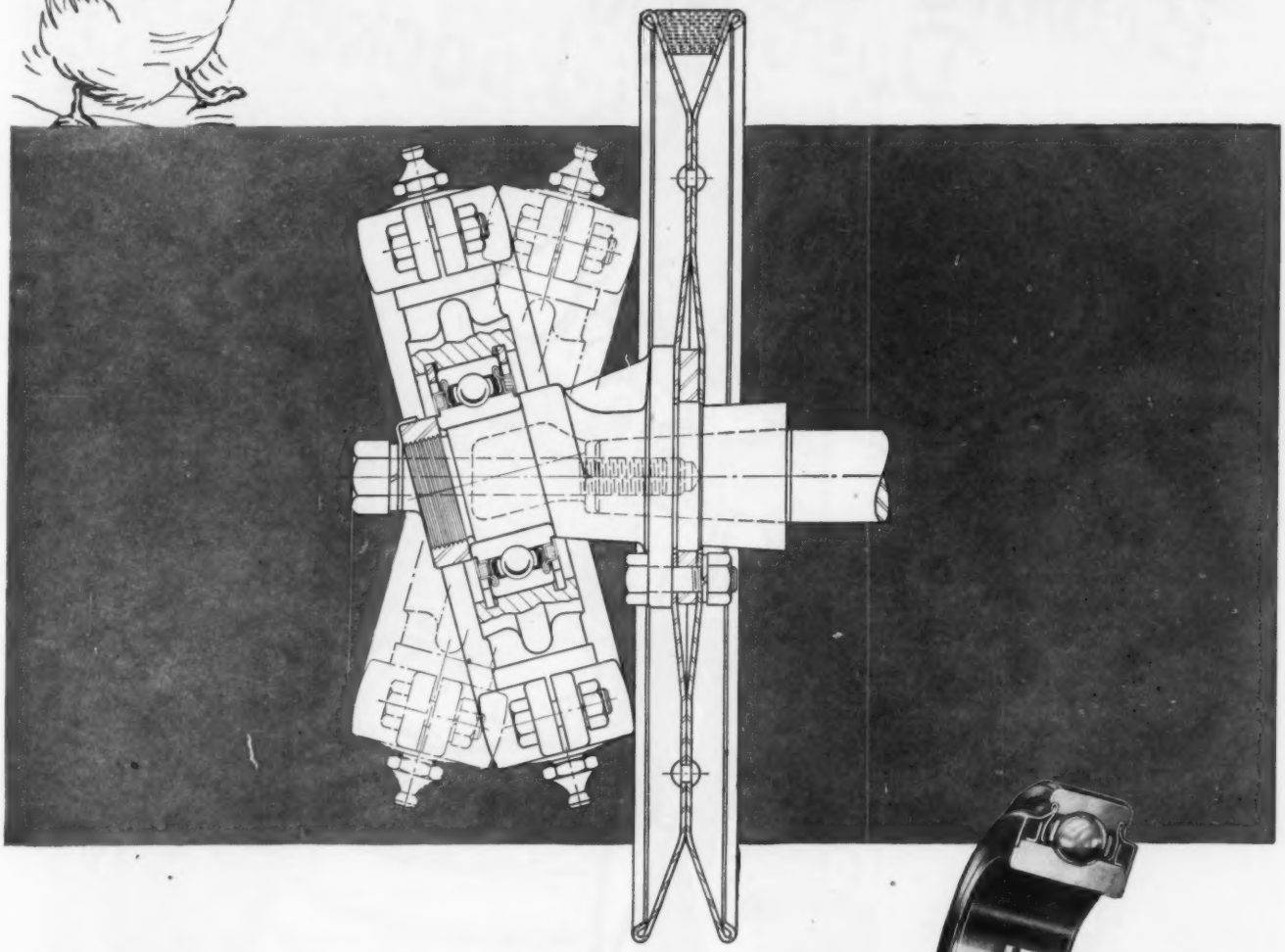
Integral-Furnace Boiler in a Southern Central Station. Capacity—300,000 lb. per hr at 1000 psi, 910 F. Oil fired with provision for future pulverized-coal firing.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
GENERAL OFFICES: 85 LIBERTY ST., NEW YORK 6, N.Y.
WORKS: ALLIANCE AND BARBERTON, O.; AUGUSTA, GA.

6375

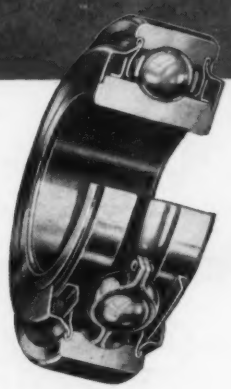
. . . THE ALWAYS WILLING WOBBLER



THIS BEARING MOUNTING gives a "wobble plate" action which is translated into oscillating motion for the sickle drive in a combine Harvester.

Such action demands a bearing that can take misaligning or thrust loads from either direction — yet will operate with minimum friction, will require no adjustment for wear. In short—a bearing that can keep a working wobbler *always willing*.

That, in a nutshell, is the New Departure self-sealed and lubricated-for-life ball bearing. It meets all these conditions squarely, and it never needs attention of *any kind* during its long life.



• New Departure self-sealed, lubricated-for-life ball bearings not only simplify design, need fewer mounting parts, but they pay dividends to the machine *user* as well. They don't take up a minute of his time. They are "built to be forgotten."

3469-C

NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN. • Branches in DETROIT • CHICAGO • LOS ANGELES and other cities

MECHANICAL ENGINEERING, June, 1947, Vol. 69, No. 6. Published monthly by The American Society of Mechanical Engineers, at 20th and Northampton Sts., Easton, Pa. Editorial and Advertising departments, 29 West 39th St., New York 18, N. Y. Price 75¢ a copy, $6.00 a year; to members and affiliates, 50¢ a copy, $4.00 a year. Postage to Canada, 75¢ additional, to foreign countries $1.50 additional. Entered as second-class matter December 21, 1920, at the Post Office at Easton, Pa., under the act of March 3, 1879. Member of the Audit Bureau of Circulations.

For Editorial Contents see page 453

Beware this Dust Hog Pickpocket!

DUST robs you of more money than it would take to get rid of it. Dust — even invisible dust — poaches light, steals from efficiency, defrauds quality of work, walks off with worker morale . . . and sends in a big bill for plant and machine maintenance. *Removing* dust costs relatively little for initial investment, practically nothing for operation.

Tell Pangborn dust control engineers about the costly "dust pockets" in your plant — and they will recommend how to clean them out. A "Dust Pocket Survey" costs you nothing — write Pangborn, *world's largest manufacturer of dust control and blast cleaning equipment*. Ask also for Bulletin 909A — all about what it takes to control dust with Pangborn systems and collectors. Address Pangborn Corporation, 289 Pangborn Boulevard, Hagerstown, Maryland.

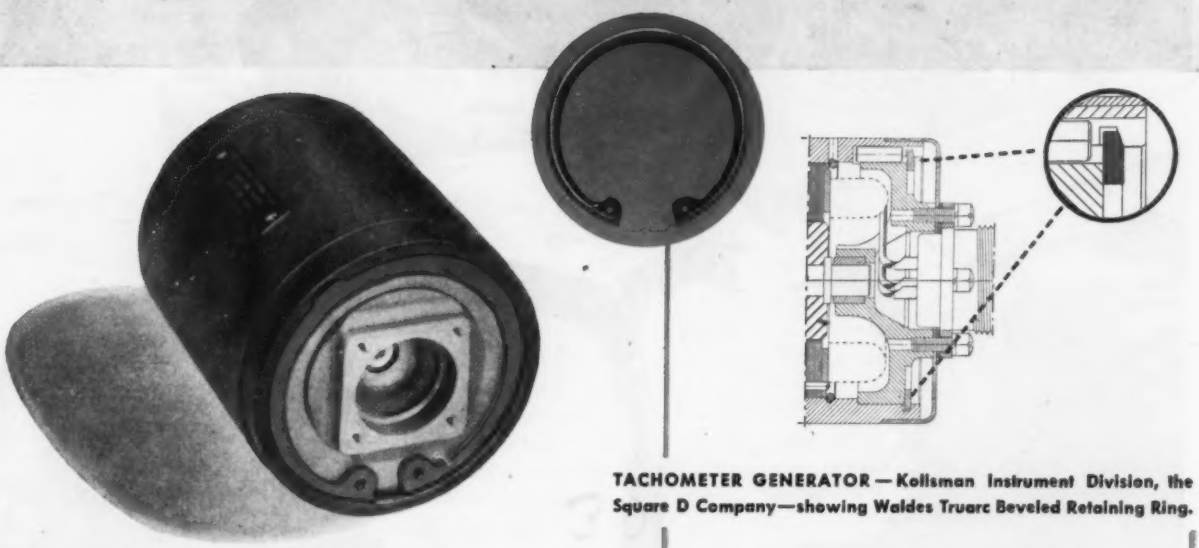
Pangborn

DUST CONTROL

PANGBORN CORPORATION HAGERSTOWN, MARYLAND

TURNS DUST LOSSES INTO PROFITS

Truarc Beveled Ring takes up end-play, eliminates shims, saves 20 minutes' assembly time



TACHOMETER GENERATOR—Kollsman Instrument Division, the Square D Company—showing Waldes Truarc Beveled Retaining Ring.

When installed in a groove with a corresponding bevel, the tapered edge of the Beveled ring acts like a wedge and rigidly bridges end-play. End-play can also be taken up resiliently by another type Truarc ring—the Bowed.

Wherever you use machined shoulders, nuts, bolts, snap rings, cotter pins—there's a Truarc ring that does a better job of holding parts together. All Truarc rings are precision engineered, easy to assemble and dis-assemble, always circular to give a never-failing grip. They can be used over and over again.

See what can be done for your product: send a drawing to Waldes Truarc Technical Service Engineers for individual attention without obligation.

One Waldes Truarc Beveled Retaining Ring gives Five big advantages:

- Secures the cover with its connecting parts in the housing against strong pressure, heavy vibration
- Absorbs accumulated tolerances up to .010 (ring diameter is 1.9375)
- Eliminates shims, saves material and weight
- Saves 20 minutes' assembly time
- Simplifies field maintenance by facilitating quick dis-assembly, re-assembly

WALDES

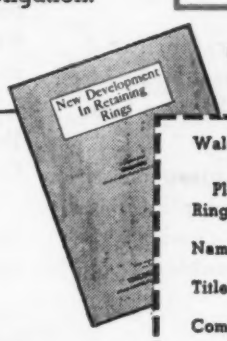
TRUARC

Reg. U. S. Pat. Off.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

Canadian Distrib.: Controlite Engineering & Sales Ltd., 20 Bloor Street W., Toronto 5



Mail this coupon today for your copy of "New Development in Retaining Rings"

Waldes Kohinoor, Inc., 47-10 Austel Place 24-P
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Please send booklet, "New Development In Retaining Rings" to:

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Title_____

Company_____

Business Address_____

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WALDES TRUARC RETAINING RINGS ARE PROTECTED BY U. S. PATS. 2,302,948; 2,006,484; 2,410,852 AND OTHER PATS. PEND.

One Special Fitting
DOES WORK OF TWO "STANDARDS"

You can see how ARMCO Steel Pipe saves time and money in these additions to three waterworks pumping stations in a large midwestern city.

Engineers on the job used special prefabricated ARMCO Steel Pipe fittings—and with good reason. *Twice* the number of standard pipe fittings would have been required to complete the work.

Special fittings like these are only one advantage of ARMCO Spiral Welded Pipe in industrial applications. The wide range of diameters (6 to 36 inches) with wall thicknesses from 7/64 to 1/2-inch, makes it possible for you to specify ARMCO Pipe in the *one right size* for the job. ARMCO Spiral Welded Pipe is easily and quickly installed because it is prefabricated to your layout. Lengths up to 50 feet, with fittings shop-welded to straight runs of pipe, mean less chance for leaks.

When ARMCO Steel Pipe is supplied with a special lining, high flow capacity is maintained indefinitely. Coatings and linings are optional.

Write for more information. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 2365 Curtis Street, Middletown, Ohio. Offices in principal cities.

EXPORT: THE ARMCO INTERNATIONAL CORPORATION

ARMCO STEEL PIPE

save your valuable time

...WITH BRUNING BW PRINTS

IN YOUR DRAFTING ROOM

Why take time to redraw worn or soiled original tracings? With the Bruning BW Process, you can salvage them quickly and easily. Just use Bruning BW Film—a transparent matte acetate safety film. This film, exposed with your tracings, provides an intermediate print from which subsequent BW prints are made. Weak lines of original tracings are intensified on the BW film and printing speed of subsequent BW prints is thereby increased. What's more, BW Eradicator may be used on BW film for removing creases or soiled areas that have been reproduced from the original.

IN YOUR ENGINEERING DEPARTMENT

Altering original designs—without changing your original tracings—is simple and easy when you use Bruning BW Transparents. Simply make a BW Transparent Print from your original—eliminating unwanted portions with BW Eradicator. New details may then be added on the BW Transparent and subsequent BW Prints made from the Transparent will bear these changes.

IN GENERAL OFFICE USE

By making bulletins, forms, charts, etc., on transparent or translucent materials, you can have as many copies as you want with BW equipment! Form letters are easily reproduced—all your typists need do is fill in headings on the same make of typewriter. Think of the repeat typing you can save! Remember, BW Prints are positive, direct line prints—not negatives, like blue prints. And BW Prints are made in seconds!

WHY USERS PREFER THE BRUNING BW PROCESS

A Bruning BW Printer-Developer can be installed anywhere in your drafting room, engineering department, office or plant. No plumbing connections are needed. You don't have to pay for exhausting unpleasant fumes because the BW Process has none. BW Printer and Developers—available in a complete line—are compact and simple, with no unnecessary gadgets to confuse your operators. Complete facts about Bruning BW equipment are yours for the asking—just mail the coupon!

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Gentlemen: I want to know more about Bruning BW Prints and equipment. Please send me information.

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Automatic Cure for Plugging of Travelling Intake Screens

Simple FOXBORO Control System operates screen whenever suction level drops . . .

HERE'S AN EASY, inexpensive way to make sure that your condenser well won't go dry if excessive refuse causes sudden plugging of the travelling screen.

Foxboro Travelling Screen Control supplements periodic screen-timing with a "judgment" that's almost human. By continuous measurement of water level on each side of the screen, this sensitive control system independently starts the cleaning action whenever a predetermined safe differential is exceeded. When correct levels are again restored, it automatically shuts down screen and spray motors. In case of unusually severe fouling of the screen, the controller can also operate a warning signal.

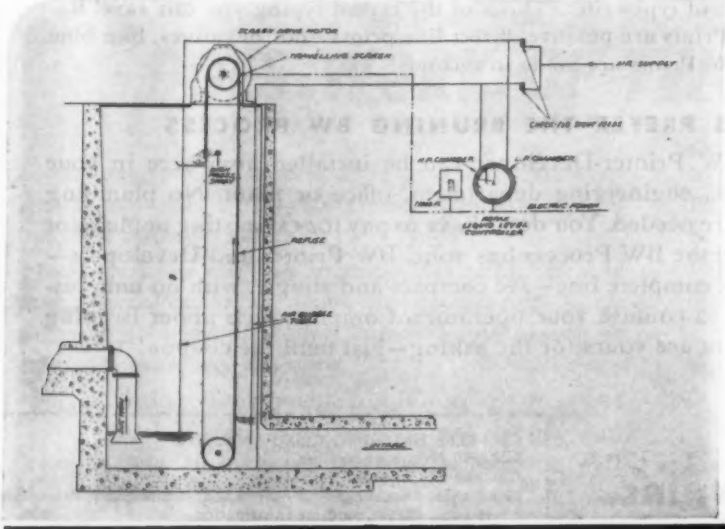
Write for complete information on Foxboro Travelling Screen Control and Bulletin 184-4 containing details of Foxboro Rotax Controllers. **The Foxboro Company, 182 Neponset Ave., Foxboro, Mass., U. S. A.**

ROTAX

Liquid Level Controller

The "heart" of Foxboro Travelling Screen Control. An extremely simple, positive-operating controller that translates level differential into operation of motors. In addition, it can operate a warning horn or light in case of unusually severe plugging.

Exclusive Rotax features include: positive electrical contact; special lock-up circuit which eliminates chattering of control relays; constant brush pressures; self-cleaning platinum contact surfaces; easy setting of control point; and freedom from maintenance.



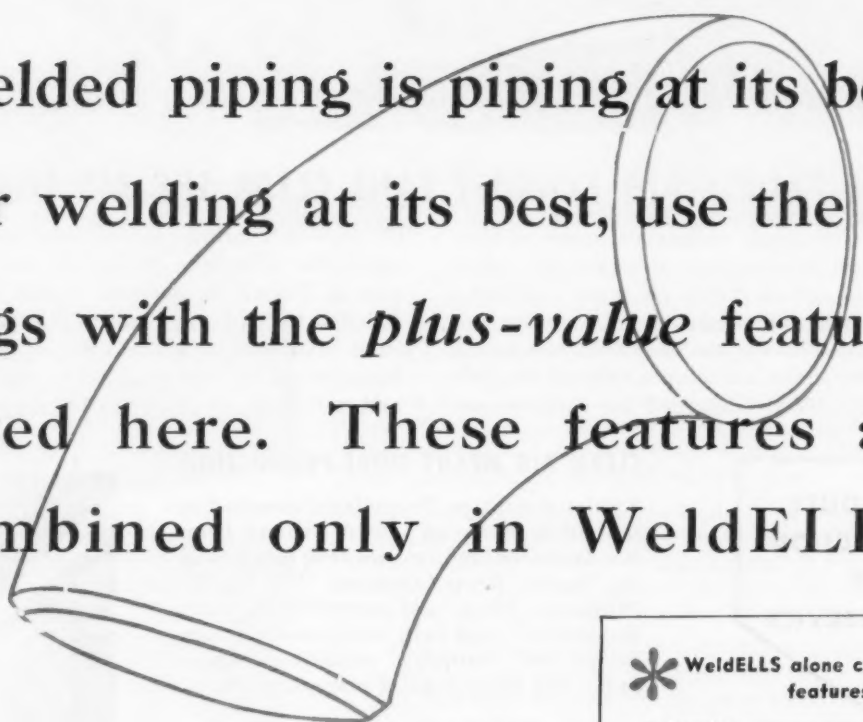
SCHEMATIC DIAGRAM, left, shows simplicity of Foxboro Travelling Screen Control System. Water level differential through the screen is continuously measured by bubble tubes. The Foxboro Rotax (electric) Controller starts and stops the screen and spray motors, as required to maintain safe differential.

FOXBORO REG. U. S. PAT. OFF.

RECORDING · CONTROLLING · INDICATING **INSTRUMENTS**

WeldELLS *have everything**

Welded piping is piping at its best. For welding at its best, use the fittings with the *plus-value* features listed here. These features are combined only in WeldELLS.



TAYLOR FORGE & PIPE WORKS

General Offices & Works: P.O. Box 485, Chicago

New York Office: 50 Church Street

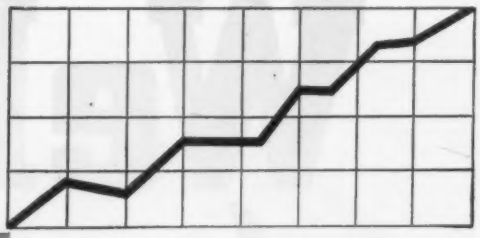
Philadelphia Office: Broad Street Station Bldg.

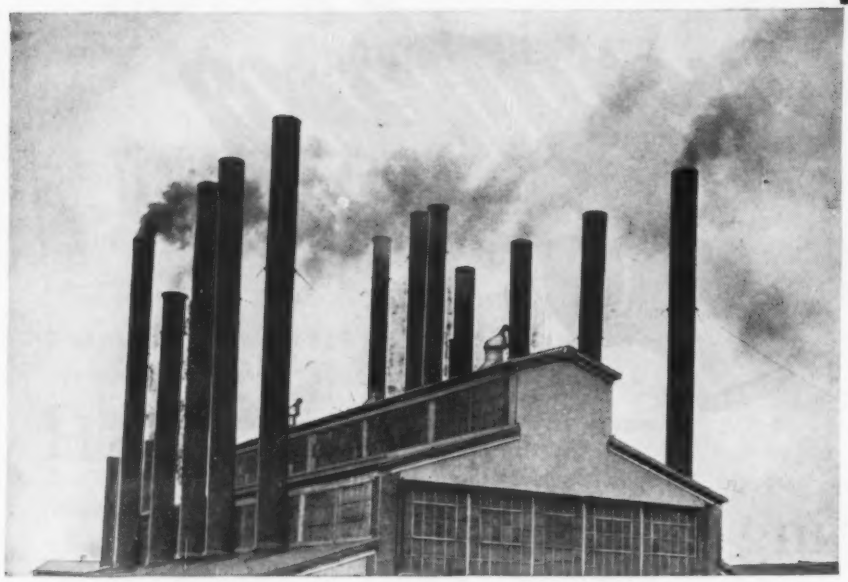
Los Angeles Office: Subway Terminal Bldg.

*** WeldELLS alone combine these features:**

- **Seamless**—greater strength and uniformity.
- **Tangents**—keep weld away from zone of highest stress—simplify lining up.
- **Precision quarter-marked ends** — simplify layout and help insure accuracy.
- **Selective reinforcement**—provides uniform strength.
- **Permanent and complete identification markings**—saves time and eliminates errors in shop and field.
- **Wall thickness never less than specification minimum** — assures full strength and long life.
- **Machine tool beveled ends** — provides best welding surface and accurate bevel and land.
- **The most complete line of Welding Fittings and Forged Steel Flanges in the World** — insures complete service and undivided responsibility.

OUT GO SMOKE AND FUMES





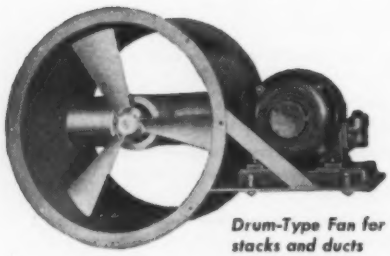
...and up goes plant production!

EFFICIENT PROPELLAIR EXHAUST FANS CLEAR THE AIR FOR ACTION

Whisk away irritating, dangerous fumes *at their source!* Exhaust smoke, dust, disagreeable odors *before* they can spread. You'll get more and better work from men and machines by keeping surrounding air clean. For *real results* in ventilating for better production, use simple, efficient Propellair fans—scientifically designed for performance.

Effective ventilating systems need not be complicated. The drum-type Propellair fan, for example, mounts directly in ducts or stacks, at any angle. Adapted to handling gases of corrosive characteristics, excessive temperatures, or high moisture. Motor is safely and conveniently outside air stream, and belt drive is protected by support tube.

HEAVY-DUTY CONSTRUCTION FOR SEVERE SERVICE



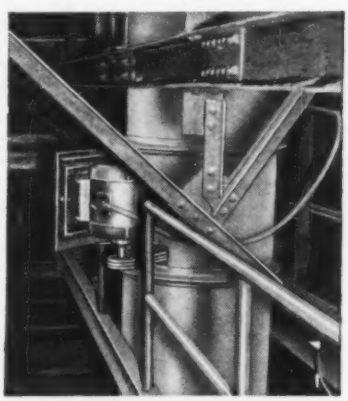
Drum-Type Fan for stacks and ducts

CLEAN AIR MEANS MORE PRODUCTION

Twelve drum-type Propellairs, installed in individual stacks as shown, exhaust from hoods shrouding brass-melting furnaces at the Mueller Brass Company, Port Huron, Michigan. They "*aid materially* in peak production" and help maintain the "*very satisfactory*" working conditions which make this plant a good place to work.

MODELS FOR EVERY NEED

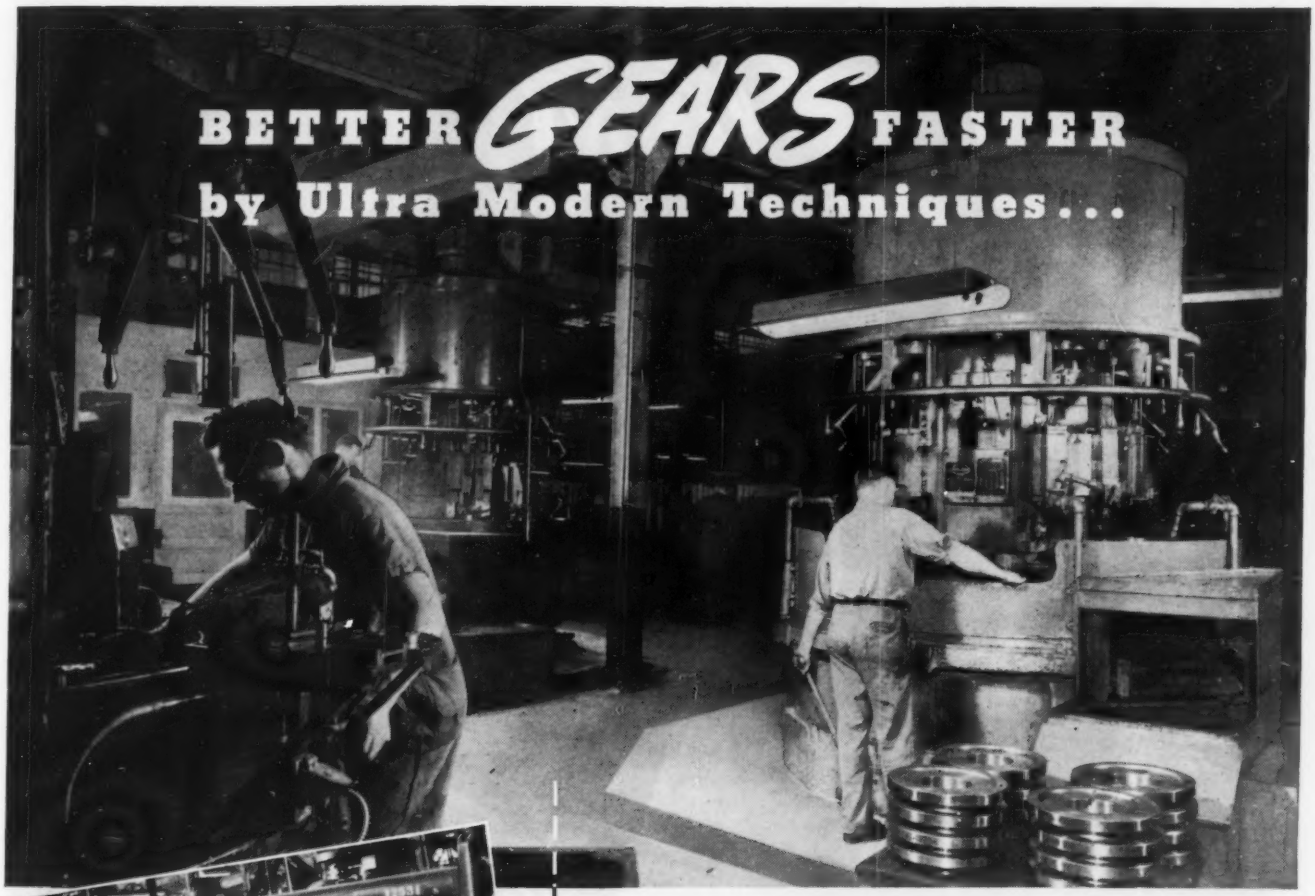
Heat, dust, moisture, and fumes *vanish* quickly and completely in the powerful suction and strong exhaust of Propellair fans. Airfoil blades *pull* even more than they *push*—deliver high volume, high velocity air output. The whole fan works—not just the tips. Types, sizes, and mountings for every industrial and commercial use. Write today for full information.

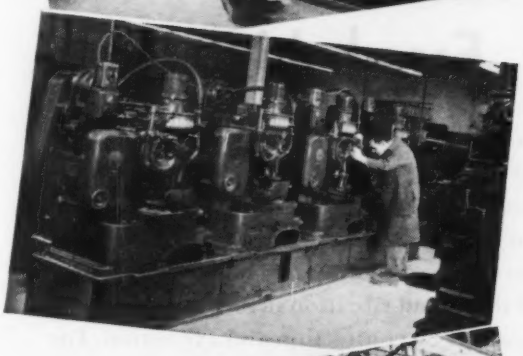


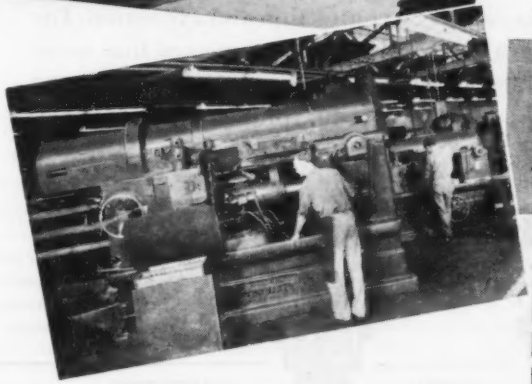
Propellair drum-type fans are actually short duct-sections—require practically no space at all. Mueller's Plant Engineer, J. W. Tielking, says, "They're easy to install in crowded quarters."

PROPELLAIR DIVISION OF ROBBINS & MYERS • INC.
SPRINGFIELD • OHIO
"Moving Air is our Business"

BETTER GEARS FASTER
by Ultra Modern Techniques...







What are your requirements in gears? Spur, helical, worm, bevel? You are probably familiar with Foote Bros. as a source for giant gears up to twenty feet in diameter, used in cement mills and sugar mill machinery. You doubtless know of the extreme precision gears this company produces for aircraft, aircraft engines and other high speed applications. Foote Bros. also manufactures high quality industrial gears for practically every purpose. A few of the many applications for these gears include gas and diesel engines, tractor transmissions, mining and construction machinery and machine tools.

In the two large plants of Foote Bros. you will find the latest in shaving, lapping and tooth grinding equipment to hob and Fellows shape any type of gear. Here also is a modern heat treating department, including physical testing and metallographic laboratories, to provide the absolute control essential to meeting exacting hardness specifications.

Back of these extensive facilities is nearly a century of manufacturing experience and an engineering staff capable of handling the toughest gear problems. We welcome the opportunity of discussing your gear requirements with you.

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 South Western Blvd. • Chicago 9, Illinois

FOOTE BROS.
Better Power Transmission Through Better Gears

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Firm.....
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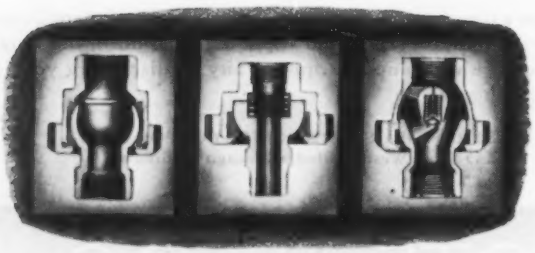
Boxing Gloves for Fuel Lines



Barco Flexible Joints are like boxing gloves—they cushion shock and impact. The best way to protect fuel lines from vibration in mechanical operation is with this famous flexible joint. In every phase of industrial activity, these expertly engineered protectors have successfully offset the onslaught of shock and vibration in fuel lines, guarded against strains caused by contraction and expansion. For full particulars about this universally accepted line, write to Barco Manufacturing Company, Not Inc., 1807 Winnemac Avenue, Chicago 40, Illinois.

BARCO FLEXIBLE JOINTS

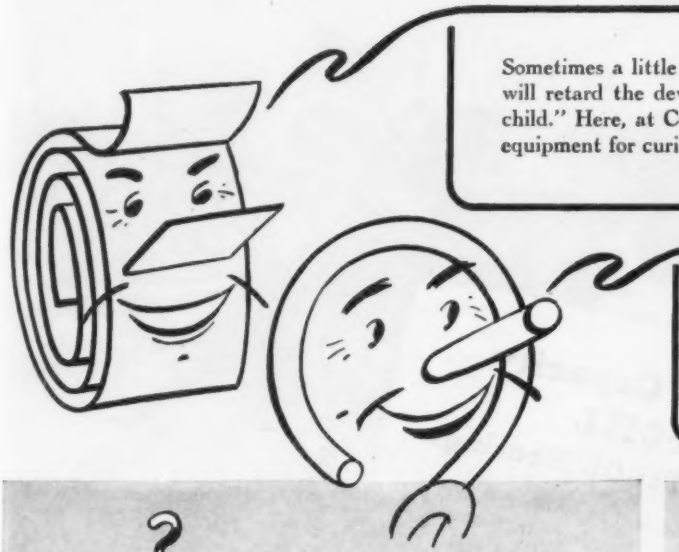
Not just a swivel joint ...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

In Canada: The Holden Co., Ltd., Montreal, Canada.

"MOVE IN EVERY DIRECTION"

WICK AND SPEN *Coil Clinic*
CAN CURE YOUR BRAIN CHILD'S HEADACHES



Sometimes a little spring can cause headaches that will retard the development of a designer's "brain child." Here, at Coil Clinic, we have the operating equipment for curing such cases.

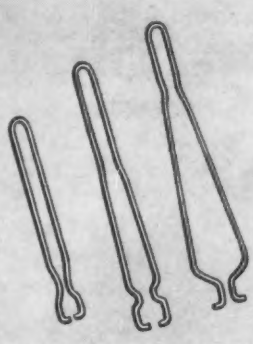
The cases brought to our clinic are given a thorough check-up by skilled technicians. They make laboratory tests, supervise forming operations, give heat treatments and build springs with plenty of muscle. Here are several of the 50,000 cases where the operations have been successful.

CASE No. 32803

By developing "U" shaped bends in the sides of this form, which is used as a box cover locking clamp, the strain is transferred from pure tension to a bending action. Clamping action is easy and positive. Because of our manufacturing know-how, production costs for this item are reasonable.

CASE No. 39673

The load-carrying capacity of this spring was increased 20° by using square wire. But the flexibility is only 70° of that of round wire of the same size. Such designs are used on machine tools, in die sets, and other applications where space limitations present a problem.



CASES No. 43610, 43612 and 43876

These wire forms are supplied for assembly with various colorful plastic pieces to make hair-do barrettes. By designing special forming tools, automatic production is entirely practical and quantity costs are very low.

CASES No. 39255 and 39889

These springs function as threaded machine parts. They are used in a household gas meter and, in case of back pressure, prevent the meter from registering in reverse. The forms were developed to meet an operating idea submitted to us.

THIS FREE BOOK MAY SAVE YOU MONEY

Our book, "Springs and Wire Forms" gives valuable data relating to spring performance, technical information, formulae and tables needed to help in proper spring selection. Write today for your free copy. Remember too, that our engineers are at your service in designing any conceivable type of springs. We've saved time and trouble for many of our customers. We can do the same for you.

WICKWIRE SPENCER

CF&I

Springs

A PRODUCT OF THE WICKWIRE SPENCER STEEL DIVISION
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Greater Load Capacity with McGILL SOLIDEND MULTIROL Bearings

The full length, rounded end rollers, used in the "Solidend" Multirol Bearing, increase the contact surface between race and rollers. This gives the McGill Bearing a greater load capacity and a longer, trouble-free life. The solid retaining end shoulders built integral with the outer race eliminate flimsy end washers and loose retaining rings. As a result "Solidend" Multirol Bearings can be used with or without the inner raceway.

An application of these bearings is in the Boom Hoist mechanism of Thew-Lorain Moto-Cranes and Crawler Mounted Machines.

For further information write for catalog SM-42.

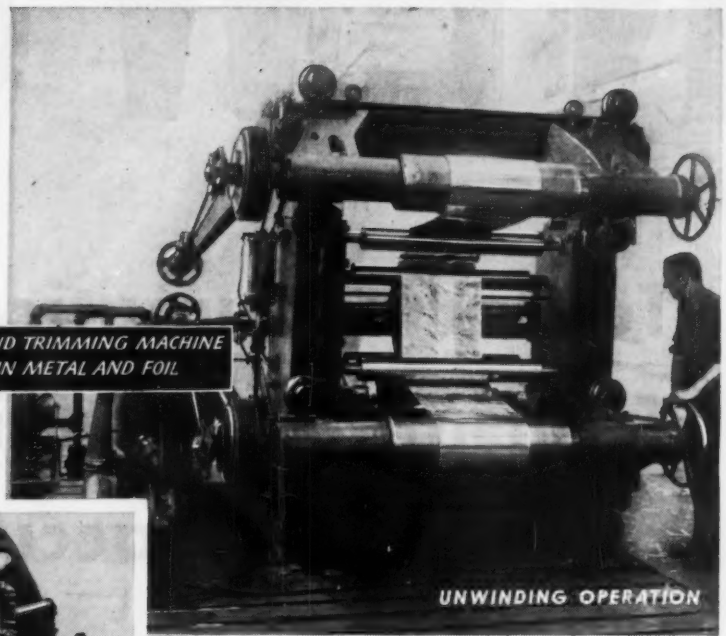
McGILL MANUFACTURING CO., INC.
Manufacturers of Ball and Roller Bearings
VALPARAISO - INDIANA

WE BUILD
ROLLING MILLS
AND ROLLING MILL EQUIPMENT

HOT AND COLD ROLLING MILLS

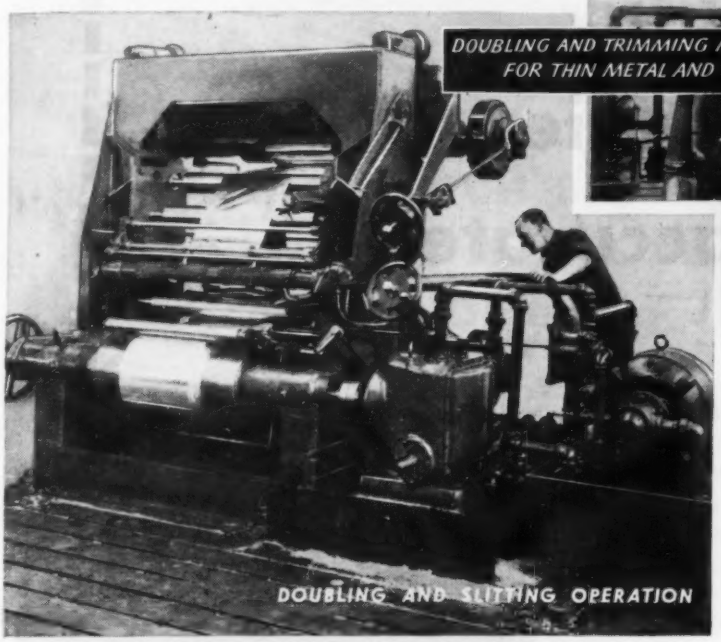
FOR FERROUS AND NON-FERROUS METALS

High Speed Mills for Thin Metal and Foil/ Rolling Mills for Blooms, Bars, Sections, Wire Rod, Plate, Sheet, Strip/Continuous Billet, Strip and Merchant Mills/Structural, Rail and Sleeper Mills, etc.



UNWINDING OPERATION

DOUBLING AND TRIMMING MACHINE FOR THIN METAL AND FOIL



DOUBLING AND SLITTING OPERATION

BY COURTESY OF THE ALUMINUM COMPANY OF CANADA LTD., INSTALLATION AT KINGSTON PLANT

ROLLING MILL AUXILIARY EQUIPMENT

Doubling and Trimming Machines/Roller Straightening Machines (Levellers)/Lifting and Tilting Tables/Shearing and Slitting Installations/Flying and Stationary Shears /Guillotine Shears/Circular Shears etc.

MODERNIZATION OF EXISTING ROLLING MILLS

MECHANIZATION OF SHEET MILLS

LET US KNOW YOUR INDIVIDUAL REQUIREMENTS AND SPECIFICATIONS

HYDROPRESS · INC.

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NEW

Taylor Pneumatic Transmitter is easier to adjust—more accurate

HERE IT IS! The new Taylor 226R Pneumatic Transmitter! Built to help keep every process in your plant right under your fingertips. And it's accurate within ½ of 1% scale range. Each transmitter is connected by a lead line to a Recording Receiver or Fulscope Controller (right) on the central control panel. You don't have to walk a step farther than that to check chart records or indications. And you can have constant remote control of temperature, pressure, rate of flow and liquid level

226R Transmitters are available with all forms of actuation for single or double duty, indicating or recording, or as single duty transmitter-controllers with any of the 5 standard types of Fulscope Control. If transmitter adjustment is ever required, it is so easily accomplished by the simple expedient of two micrometer screws—one for range and the other for zero setting.

Ask your Taylor Field Engineer for full details. Also ask him about "Transet"—our new transmission system that eliminates time lag and cuts panel space to 1/3. Write for Bulletin 98156. Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada. *Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.*

TAYLOR INSTRUMENTS MEAN ACCURACY FIRST

Now Available for Prompt Delivery. A New INCH SIZE Line of Low Cost Unground Radial Bearings with Solid Inner and Outer Rings and Ball Retainer.

3000 SERIES DIMENSIONS AND LIST PRICES

BEARING NUMBER			BORE	OUTSIDE DIAMETER		WIDTH	CORNER RADIUS	BALL DIAM.	LIST PRICE	CODE WORD		
NO SHIELDS	SINGLE SHIELD	DOUBLE SHIELD	INCHES +.005 −.000	INCHES	TOLERANCE +.0000 TO MINUS	INCHES +.005 −.003	INCHES	INCHES		NO SHIELDS	SINGLE SHIELD	DOUBLE SHIELD
3001NS	3001SS	3001DS	3-16	11-16	−.0005	1-4	.015	1-8	.45	JENBE	JIBBE	JODBE
3002NS	3002SS	3002DS	1-4	11-16	−.0005	1-4	.015	1-8	.45	JENAB	JIBAB	JODAB
3005NS	3005SS	3005DS	5-16	29-32	−.0005	5-16	.015	1-8	.45	JENCH	JIBCH	JODCH
3006NS	3006SS	3006DS	3-8	29-32	−.0005	5-16	.015	1-8	.45	JENFO	JIBFO	JODFO
3007NS	3007SS	3007DS	7-16	29-32	−.0005	5-16	.015	1-8	.50	JENGU	JIBGU	JODGU
3014NS	3014SS	3014DS	3-8	1 1-8	−.0005	3-8	.025	3-16	.50	JENDJ	JIBDJ	JODDJ
3015NS	3015SS	3015DS	7-16	1 1-8	−.0005	3-8	.025	3-16	.50	JENEN	JIBEN	JODEN
3016NS	3016SS	3016DS	1-2	1 1-8	−.0005	3-8	.025	3-16	.50	JENHA	JIBHA	JODHA
3020NS	3020SS	3020DS	7-16	1 3-8	−.0005	7-16	.025	7-32	.55	JENIC	JIBIC	JODIC
3021NS	3021SS	3021DS	1-2	1 3-8	−.0005	7-16	.025	7-32	.55	JENLD	JIBLD	JODLD
3022NS	3022SS	3022DS	9-16	1 3-8	−.0005	7-16	.025	7-32	.55	JENJF	JIBJF	JODJF
3023NS	3023SS	3023DS	5-8	1 3-8	−.0005	7-16	.025	7-32	.55	JENNK	JIBNK	JODNK
3033NS	3033SS	3033DS	5-8	1 3-4	−.0005	1-2	.025	1-4	.75	JENPS	JIBPS	JODPS
3034NS	3034SS	3034DS	11-16	1 3-4	−.0005	1-2	.025	1-4	.75	JENRZ	JIBRZ	JODRZ
3035NS	3035SS	3035DS	3-4	1 3-4	−.0005	1-2	.025	1-4	.75	JENSV	JIBSV	JODSV
3038NS	3038SS	3038DS	3-4	2	−.0006	9-16	.035	1-4	.90	JENTW	JIBTW	JODTW
3039NS	3039SS	3039DS	13-16	2	−.0006	9-16	.035	1-4	.90	JENUM	JIBUM	JODUM
3040NS	3040SS	3040DS	7-8	2	−.0006	9-16	.035	1-4	.90	JENVT	JIBVT	JODVT
3041NS	3041SS	3041DS	1	2	−.0006	9-16	.035	1-4	.90	JENWG	JIBWG	JODWG

Outside diameter has ground finish to indicated tolerances.

Corner Radius indicates maximum fillet radius in housing or on shaft which bearing radius will clear.

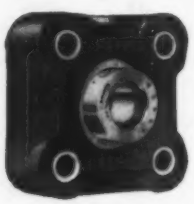
The above list prices apply to 3000 DS, SS and NS types for quantities up to 99 pieces. See discounts on page 6, Catalog No. 125 or 125A. Write for special net prices on larger quantities.

NICE

NICE BALL BEARING COMPANY

NICETOWN · PHILADELPHIA · PENNSYLVANIA

Wide inner ring ball bearing with exclusive self-locking collar for slip-fit assembly and disassembly
Single-row radial ball bearing
Prelubricated to last for years and sealed with integral steel shields
Wire spring in base for grounding electrical charges
Inch-dimension bore sizes up to 1 3/16" for popular shaft sizes.
Housing of high-grade, long-life molded synthetic rubber, into which bearing is fitted. For extra rigidity, cadmium plated steel strap is available.
Steel bushing reinforced bolt holes
FAFNIR
FOR LIGHT-DUTY APPLICATIONS
Save Money
REDUCE
Noise and Vibration
Fafnir Rubber-Mounted Ball Bearing Units



. . . also rubber mounted flange and cylindrical cartridges

HERE'S A BEARING BARGAIN for manufacturers of small fans, domestic heating, ventilating and air-conditioning equipment, and small conveyor systems. In one economy-priced package you get low starting torque to save motors, up to 10% power saving, automatic lubrication, self-maintenance, and faster, simpler assembly . . . all wrapped up in a noise and vibration absorbing synthetic rubber mounting. It's a competitive advantage for you tagged with a bargain price. Write for descriptive folder showing complete line of rubber-mounted units. The Fafnir Bearing Company, New Britain, Conn.

MOST COMPLETE LINE IN AMERICA — FAFNIR BALL BEARINGS

VIBRATION — It's hidden... in high costs

Control it with

LORD

SHEAR TYPE

Bonded Rubber

MOUNTINGS

Right now—this minute—and in your plant . . . *you're losing money.* The cause . . . VIBRATION! You can't see it—it's hidden . . . but you can see vibration's costly results on your profit and loss statement . . . in high costs—directly attributable to industrial fatigue, lagging production, inferior accuracy, excessive scrap and shortened machine life.

Vibration can be controlled . . . and doing that you can raise your plant efficiency and morale, your product quality, and your profits. For immediate action, contact the nearest Lord Field Engineer or Lord direct. Let him analyze your product . . . in countless cases efficient application of Lord Vibration Mounts has surprisingly improved product performance. And ask him to check factory equipment . . . possibly a relatively simple solution can eliminate vibration, making your plant a better place to work—and a better working plant.

A quarter-century of scientific research and experience in the field of Vibration Control and Bonded Rubber Products backs up our recommendations. Put us to work on your problems . . . make Lord your Headquarters on Vibration Control.

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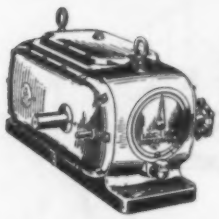
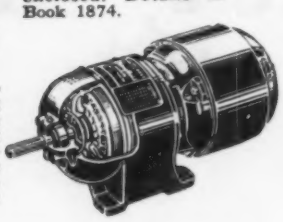
Keep Production Up with *Efficient* LINK-BELT POWER TRANSMISSION MACHINERY

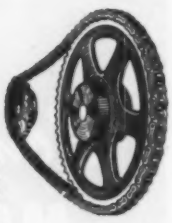


P.I.V. Gear Speed Changer permits infinite variation of speed while machine is running; holds set speed indefinitely, without slip or creep. All metal wholly enclosed. Details in Book 1874.



Electrofluid Drive combines hydraulic coupling with standard induction motor; reduces starting current; avoids "overmotoring" — absorbs shock; protects machinery. Details in Book 2085.

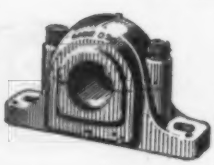
Silverstreak Silent Chain Drive gives positive, flexible transmission without slip at high speeds. Runs slack on short centers. Ask for Data Book 125.



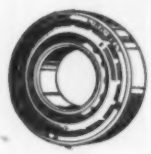
Silverlink Roller Chain Drive for high or low speed transmission; coordinating rotation of several shafts in either direction; short or long centers. Single or multiple widths. Details in Book 1957.

Steel, Promal and Malleable Chain Drives where extraordinary strength is needed, on slow and medium speeds, these chains are the standard by which performance is gauged. Data Book 1994.

Ball Bearing Mounted Units for light and medium duty. Pillow blocks, with solid or split housings, flanged, cartridge and take-up units, self-aligning, in fixed or floating types. Ask for Book 2094.



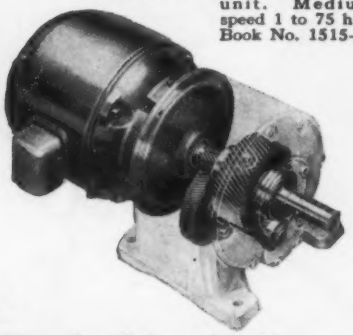
Roller Bearing Mounted Units for heavy duty service, self-aligning, for fixed or floating shafts, press-fit or adapter type, in split pillow blocks. Ask for Book 2095.

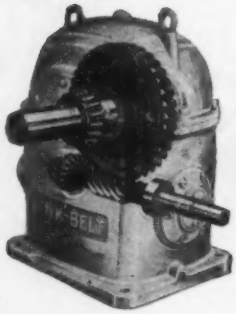


Unmounted Ball and Roller Bearings provide self-alignment for radial, thrust or combination loads. Offer great economy of application. Details in Books 2094 and 2095.

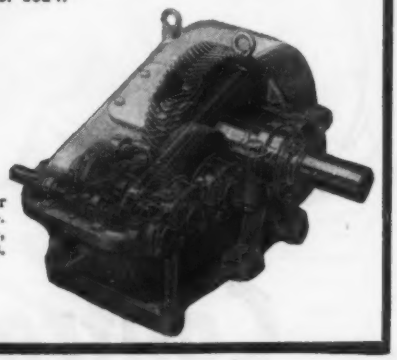
Babbitted Bearings in widest selection of types; solid or split housing; grease or self-oiling; light and heavy duty service. Data in Book 1997.

Motorized Helical Gear Speed Reducer, self-contained power unit. Medium speed 1 to 75 h.p. Book No. 1515-A.





Worm Gear Reducers for high ratio reductions horizontal or vertical drive shafts. Data in Book No. 1824.



Herringbone Gear Reducers for large reductions in limited space. High shock resistance. Single, Double or Triple Reductions. Data Book No. 1819.

THERE'S A LINK-BELT SPEED REDUCER FOR EVERY SITUATION AND SERVICE

Any industrial application for a speed reducer can be filled with a Link-Belt unit — and satisfactory results assured. Link-Belt manufactures all three standard types, and Link-Belt power transmission specialists can offer reliable recommendations as to size and type to suit your precise need.

In respect to any unit in the broad Link-Belt line, Link-Belt engineering advice on your power transmission problems is completely unbiased.

10,320

LINK-BELT COMPANY

The Leading Manufacturer of Conveying and Mechanical Power Transmission Machinery

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities.

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LINK-BELT *Power Transmission Machinery*

Want Tighter Control Over Parts Cost?...

A BULLETIN SERVICE

for users of forgings, entitled "Advantages Obtained by Utilizing Champion Forging Techniques", gives complete information abou cost reductions and quality control achieved by forging specific parts in closed impression dies.

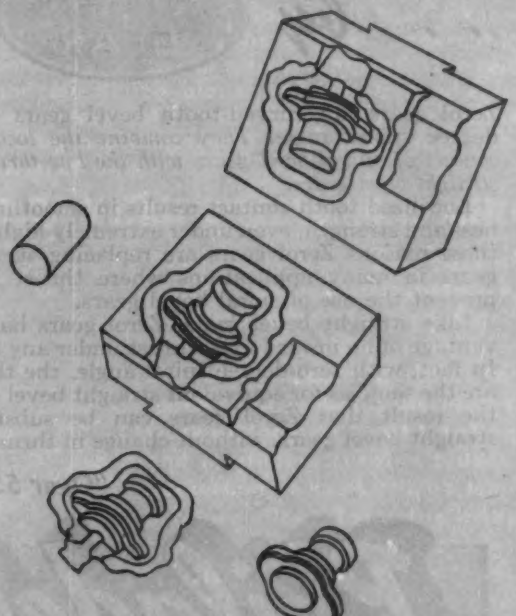
. . . Buy Forgings . . .

Close Tolerance Forgings Produced by

Champion

FORGING TECHNIQUES

● Tighter control over the cost of parts begins with engineering and design and involves every handling and production operation, including the final machining or finishing. The scope of Champion Forging Techniques likewise comprehends every step and stage of production clear through to the end use or application of a part. Thus, forgings produced by Champion Forging Techniques may present to you opportunities, which are often unappreciated or overlooked, to obtain and maintain a tighter control over end-use cost. For instance, in the production of a certain part, a slight change in design, unimportant in the function of the part but of major importance in forging the metal to form it, was recommended, resulting in notable reductions in the cost of jigs and tools and machining and finishing. Ask a Champion Forging Techniques Engineer about tighter control over the cost of parts weighing from a few ounces to over 1300 lbs.

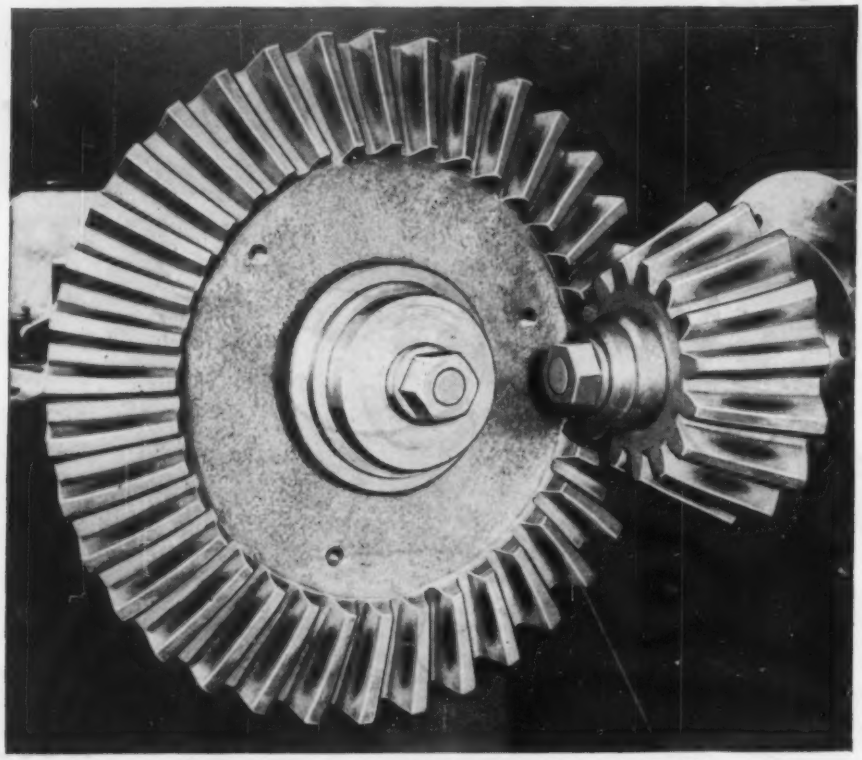


THE CHAMPION MACHINE & FORGING COMPANY

3697 EAST 78th ST. • CLEVELAND 5, OHIO

DROP AND UPSET FORGINGS, CARBON AND ALLOY STEELS • HEAT TREATING • LABORATORY AND QUALITY CONTROL

And now - "ZEROL" GEARS



Testing a large pair of Zerol gears, 15 x 36 combination, 1 D.P. These gears were cut on a Gleason Planing Generator for large spiral bevel gears. Although the teeth appear to be almost straight, they are actually slightly curved from end to end. The difference in curvature between the gear and pinion teeth controls the length of tooth contact.

. . . by PHILLIE GEAR . . . up to 48" diameter

Zerol gears are curved-tooth bevel gears with zero-degree spiral angle. *They combine the localized tooth contact of spiral bevel gears with the low thrust loads of straight bevel gears.*

Localized tooth contact results in smoothness, quietness and strength, even under extremely high loads. For these reasons Zerol gears are replacing straight bevel gears in many applications where thrust limitations prevent the use of spiral bevel gears.

Like straight bevel gears, Zerol gears have the advantage of no inward axial thrust under any conditions. In fact, with zero-degree spiral angle, the thrust loads are the same as for equivalent straight bevel gears, with the result that Zerol gears can be substituted for straight bevel gears, without change in thrust bearings.

Zerol gears, like other bevel gears, are designed with long and short addendum tooth proportions for smooth, quiet operation, and with large fillet radii for maximum strength.

Large Zerol bevel gears, when required, have their teeth (only) hardened on our own surface hardening machine, while smaller ones, where necessary, are hardened by the induction, straight heat treating or case hardening methods.

These gears give localized tooth bearing, which decreases stress, greatly lengthens gear life, and minimizes breakage.

We are in a position to cut gears of the Zerol bevel type up to 48" in diameter. Write us for further information.

"Over 55 Years Gear Making Experience"

Philadelphia GEAR WORKS INCORPORATED

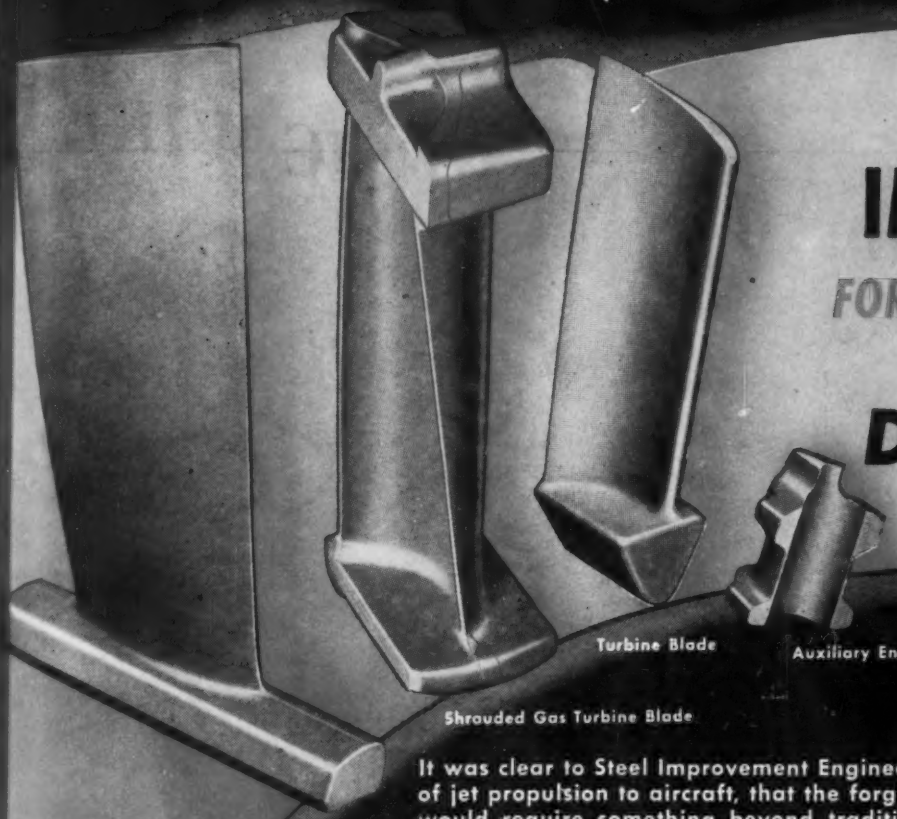
ERIE AVE. AND G ST., PHILADELPHIA 34, PA.

NEW YORK • PITTSBURGH • CHICAGO . . . IN CANADA: WILLIAM AND J. G. GREEY LIMITED, TORONTO

Industrial Gears and Speed Reducers
LimiTorque Valve Controls

STEEL IMPROVEMENT

FORGED TURBINE BLADES ARE ALWAYS Dependable



Turbine Blade

Auxiliary Engine Turbine Blade

Shrouded Gas Turbine Blade

Axial Flow Compressor Blade

It was clear to Steel Improvement Engineers, at the initial stage in the application of jet propulsion to aircraft, that the forging of turbine blades, buckets and wheels would require something beyond traditional forging techniques. There followed the immediate adoption of an attitude in which the urge to pioneer, to persist in the effort to discover and establish correct techniques for forging high temperature alloys to close tolerances, was given the utmost freedom of action. Responding to the irrepressible urge to forge correctly these essential parts, funds were generously appropriated at the beginning to obtain or develop suitable equipment and to conduct experimental forging. Success crowned this effort. Thousands of these vital parts have been formed of the new high temperature alloys by drop forging to close tolerances. On the basis of long experience in forging intricate designs, and of the specialized metallurgical and engineering skill acquired, it is now possible for Steel Improvement Forging Engineers and Metallurgists to: (1) know the exact forging technique that should be utilized for developing fully the qualities, inherent in the alloy, that are required to meet the high stresses occurring in modern aircraft engines; (2) avoid costly experimentation in forging, heat treating and machining blades, buckets and wheels; (3) advise and assist designers regarding the correct placement of parting lines and other design elements; and (4) adhere strictly to a policy of projecting a promise only when the accomplishment of the work can be substantiated by fact or experience or both.

THE VITAL ELEMENT IN THE IMPROVEMENT OF METALS BY FORGING IS MEN!

Backed by over 33 years of forging production experience, Steel Improvement Engineers and Metallurgists have under their direction complete facilities for performing the highly specialized work of forging, heat treating and machining turbine blades, buckets and wheels of high temperature alloys. These facilities constitute a Turbine Forgings Division, the authority and responsibility of which encompasses all required phases of engineering, metallurgy, production and inspection to assure you dependable forgings.

Turbine Forgings Division

DROP FORGINGS

THE STEEL IMPROVEMENT & FORGE CO.

952 East 64th Street CLEVELAND, OHIO

Sales Offices: New York • Chicago • Milwaukee • Tulsa • Los Angeles

Improvising on SPRING MUSIC WIRE

When spring "specs" say: "Make it of music wire"—we could call it a day. Music wire is a well-known standard product and lots of springs are made of it. But with a particular eye to production and performance balance, we use several kinds of music wire, each keyed to special uses. By broadening the field of "standards," Wallace Barnes provides additional possibilities for quality control and economy in springmaking.

Sharp with the "Flats," too!

For flat springs and small stamped parts, Wallace Barnes also processes in its own mill many tempers and hardnesses of spring steel to meet requirements of intricacy or endurance.

Wallace Barnes SPRINGS

SMALL STAMPINGS • WIRE FORMS • HAIRSPRINGS • COLD ROLLED SPRING STEEL

WALLACE BARNES COMPANY
BRISTOL, CONN.
DIVISION OF THE ASSOCIATED SPRING CORP.

AND IN CANADA, THE WALLACE BARNES CO., LTD., HAMILTON, ONTARIO

PLANS CALL FOR HANDLING LIQUIDS?

. . . here's data you'll want to have in your files

There are quite a few engineers who still rely on a gauge stick, glass reading or weighing by scales as a means of measuring liquids in processing. But the modern method of accounting for liquids is by metering. It is the only method that has been found to be thoroughly accurate.

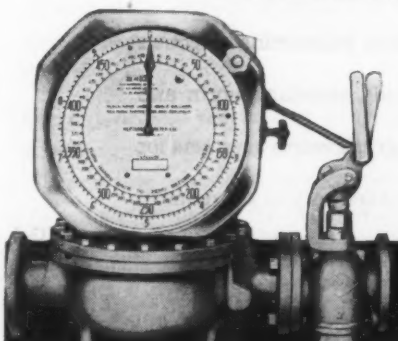
Neptune Liquid Meters save time, money, worry—stop waste and stabilize production by providing, within the rates of flow for which they are recommended, consistently accurate measurements. They are backed by 50 years experience in handling more than 88 different liquids, from Acetone to Xylol.

Construction of the meter is simple, there being only one moving part in the measuring chamber—the piston. The dial operates like a clock, the large black hand showing single gals; lbs; or other units of measurement, and the small hand indicating tens and hundreds of gals; lbs; etc.

Totalizing register is accumulative, providing accounting tabulations for hourly, daily, weekly, monthly or yearly recordings. Auto-Stop feature automatically cuts off flow after preset quantity has been delivered.

What's *your* liquid handling problem? Coupon below is for your convenience.

LIMITATIONS: Because our meters are made of copper bearing alloys, they cannot be used for measuring certain chemicals corrosive to copper; particularly food products containing acids of any kind, such as acetic and citric acids; also in other food products where necessary sterilization cannot be obtained, such as beer and milk.



NEPTUNE METERS

NEPTUNE METER COMPANY, 50 West 50th Street, New York 20, N. Y.

Gentlemen: I would like to have information on metering _____ with a flow rate of _____ gals. per min.
(mention type of liquid)

NAME AND TITLE.....

COMPANY.....

ADDRESS.....

CITY..... ZONE..... STATE .....

for Every User of Worm Gears

This new 48-page, data-filled catalog gives all the information necessary for the selection of correct worm and gear sets for any given requirement. It includes information concerning selection practice, worm gear rating tables, instructions for computing bearing loads, standard worm and gear dimensions and other information necessary to those requiring high grade worm gear sets for use in their own equipment. A copy of this important catalog will be mailed to you on request.

WG-4

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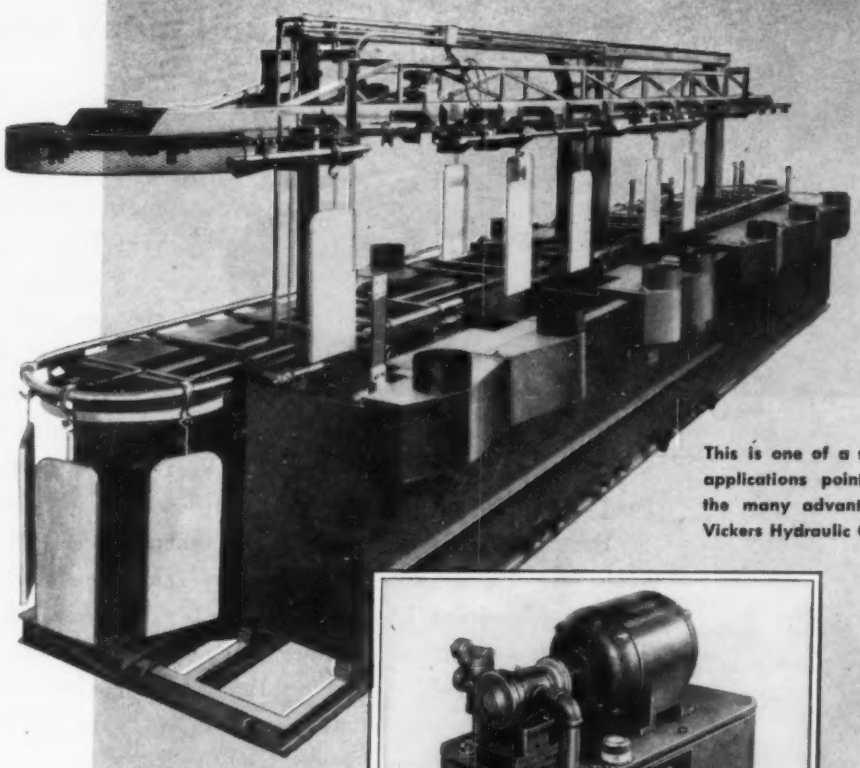
VICKERS HYDRAULIC EQUIPMENT

helps achieve

HIGH PRODUCTION
SPACE ECONOMY
UNIFORM QUALITY

IN *Udylite* AUTOMATIC PLATING MACHINE



This is one of a series of applications pointing out the many advantages of Vickers Hydraulic Controls.

Above: Elevated position for transfer from one tank to the next.

Vickers Hydraulic Power Unit.

This Udylite machine does a complete plating job automatically . . . taking each part through seven tanks and a drying chamber . . . timing exactly the interval in the various solutions for cleaning, plating and rinsing.

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Udylite made the machine far more compact—saving 18″ to 24″ in the length of each tank—by using Vickers Hydraulic Equipment to raise and lower the entire conveyor assembly at each transfer. By this means, each piece (or rack) is lifted straight out of the tank, moved over the next tank and lowered straight down. This provides better cleaning and more uniform plating—better drainage and less contamination of the solutions.

The Vickers Hydraulic Power Unit and Control Valves have many advantages for such applications: (1) proven dependability, (2) accurate control and precise timing, (3) flexibility of control to suit varied production requirements, etc.

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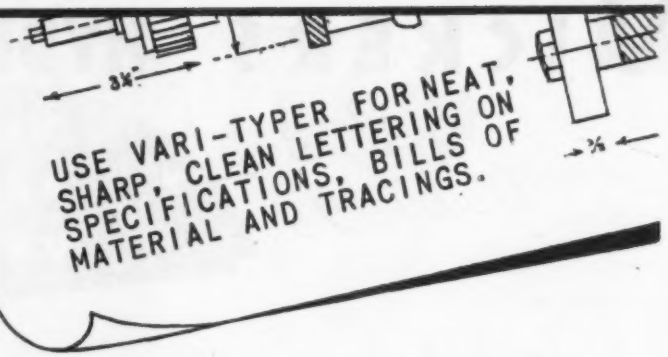

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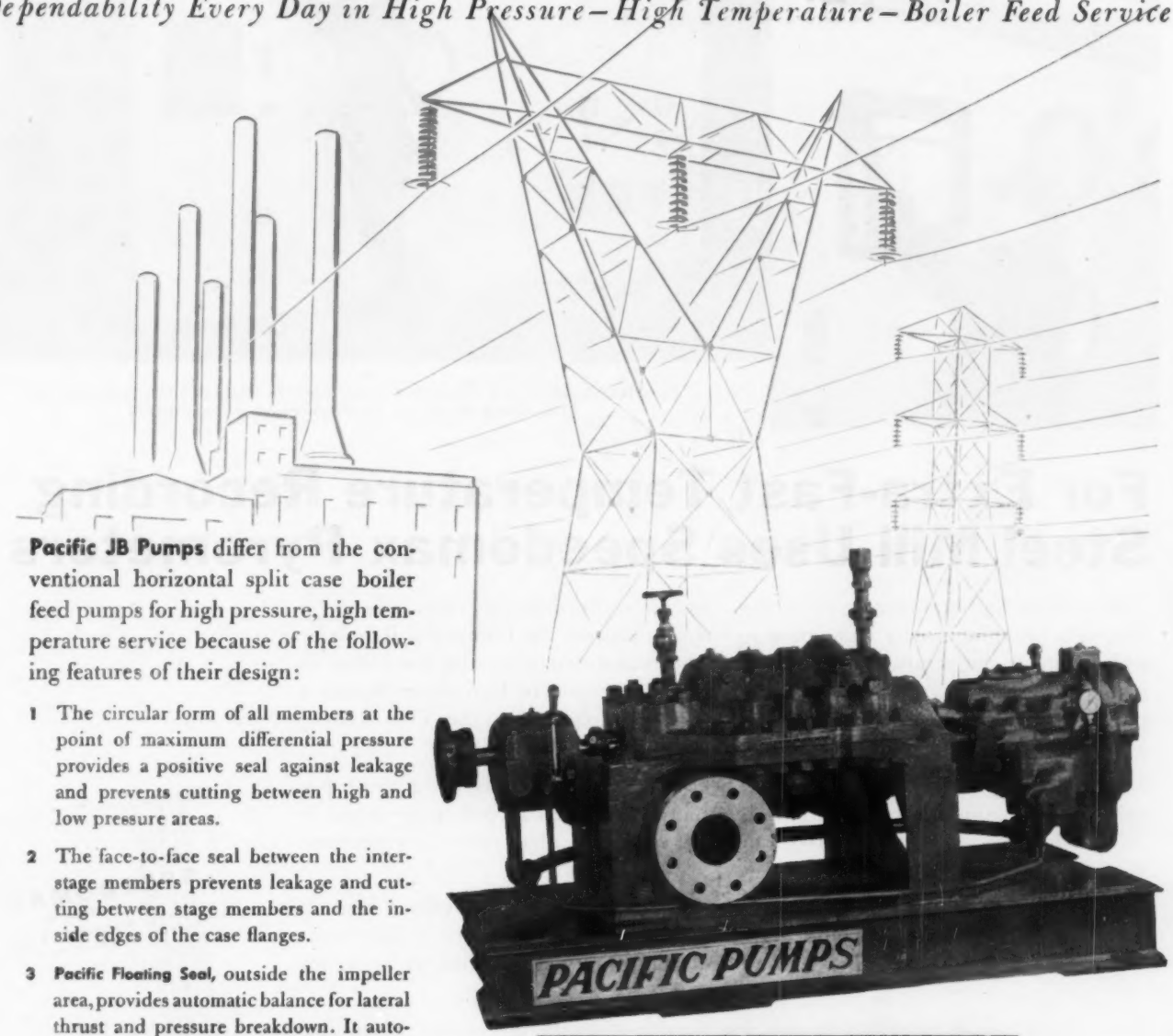

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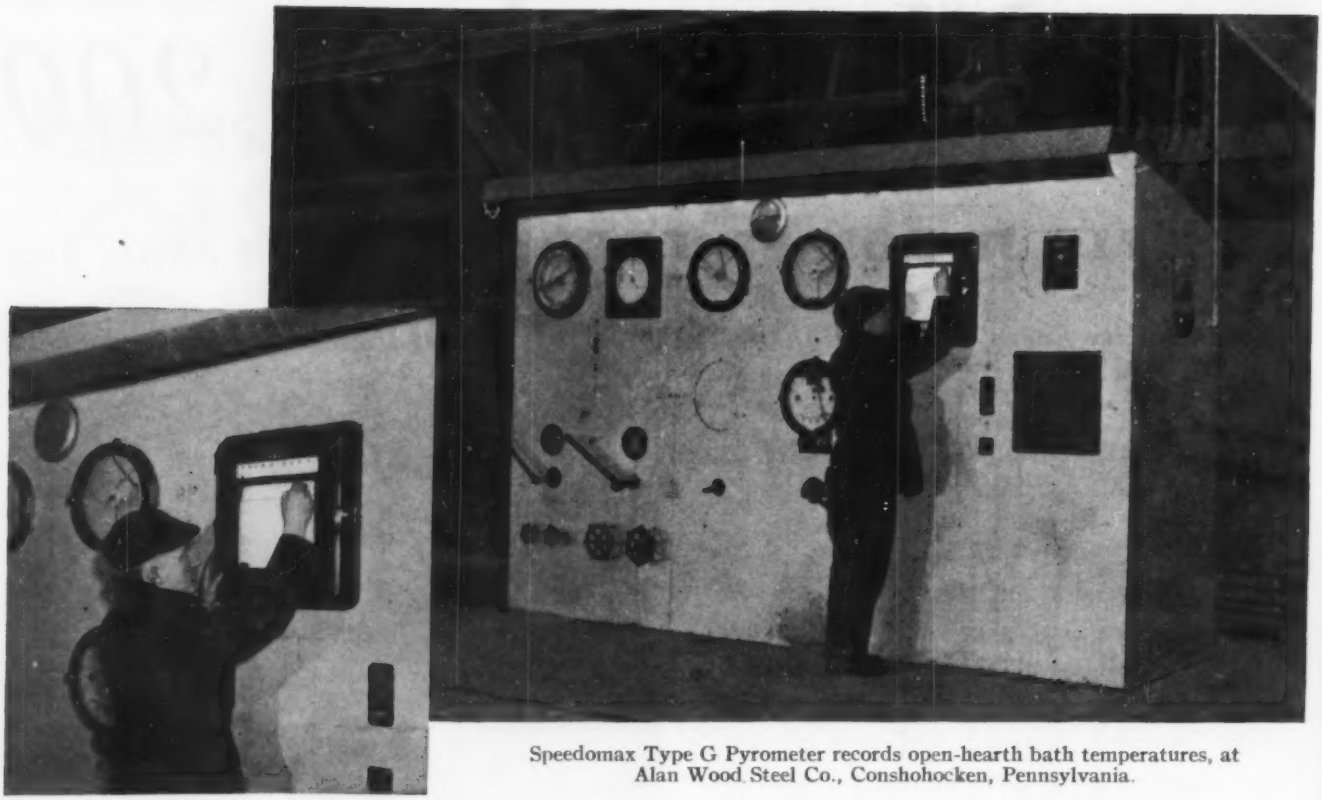

Speedomax Type G Pyrometer records open-hearth bath temperatures, at Alan Wood Steel Co., Conshohocken, Pennsylvania.

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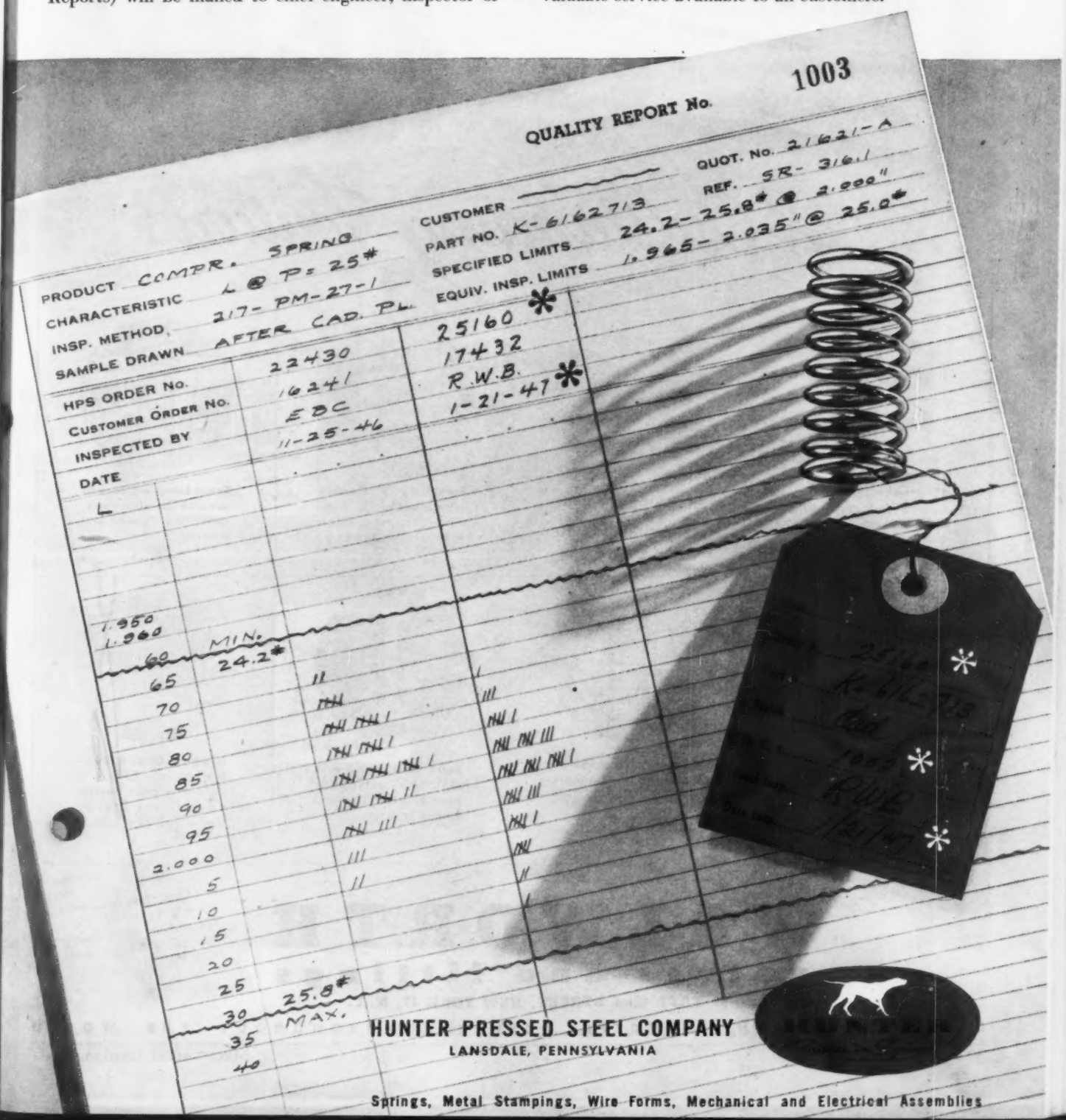
These reports enable one to compare quality lot-for-lot, consider tolerance revisions, reduce customers' sampling without sacrificing quality insurance . . . will lead eventually to a comparison of quality vendor-for-vendor.

Hunter believes it is the first in industry to make this valuable service available to all customers.



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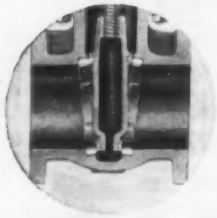
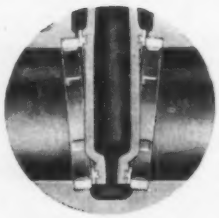
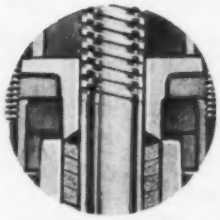


Straight-Flow Port Design reduces fluid turbulence to a practical minimum.

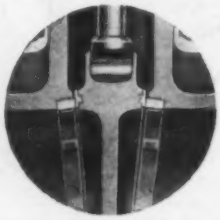


Seat Rings of end-seated type are screwed into the body.

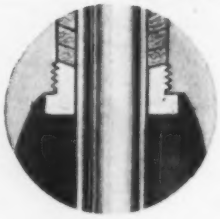
Sure-Grip Malleable handwheel for non-skid gripping even with heavy gloves.



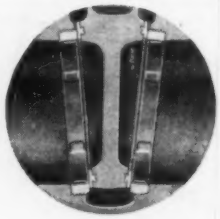
Brass Liner on Glands assures greater resistance to corrosion and scoring.



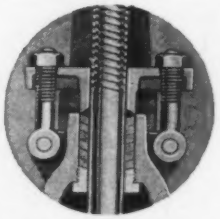
T-head disc-to-stem connection on OS&Y types provides stronger connection, prevents loosening of disc by corrosion.



Bronze back-seat bushings in bonnets of OS&Y valves.



Solid Web Type disc in OS&Y valves for greater strength and longer service.



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MECHANICAL ENGINEERING

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VOLUME 69 NUMBER 6

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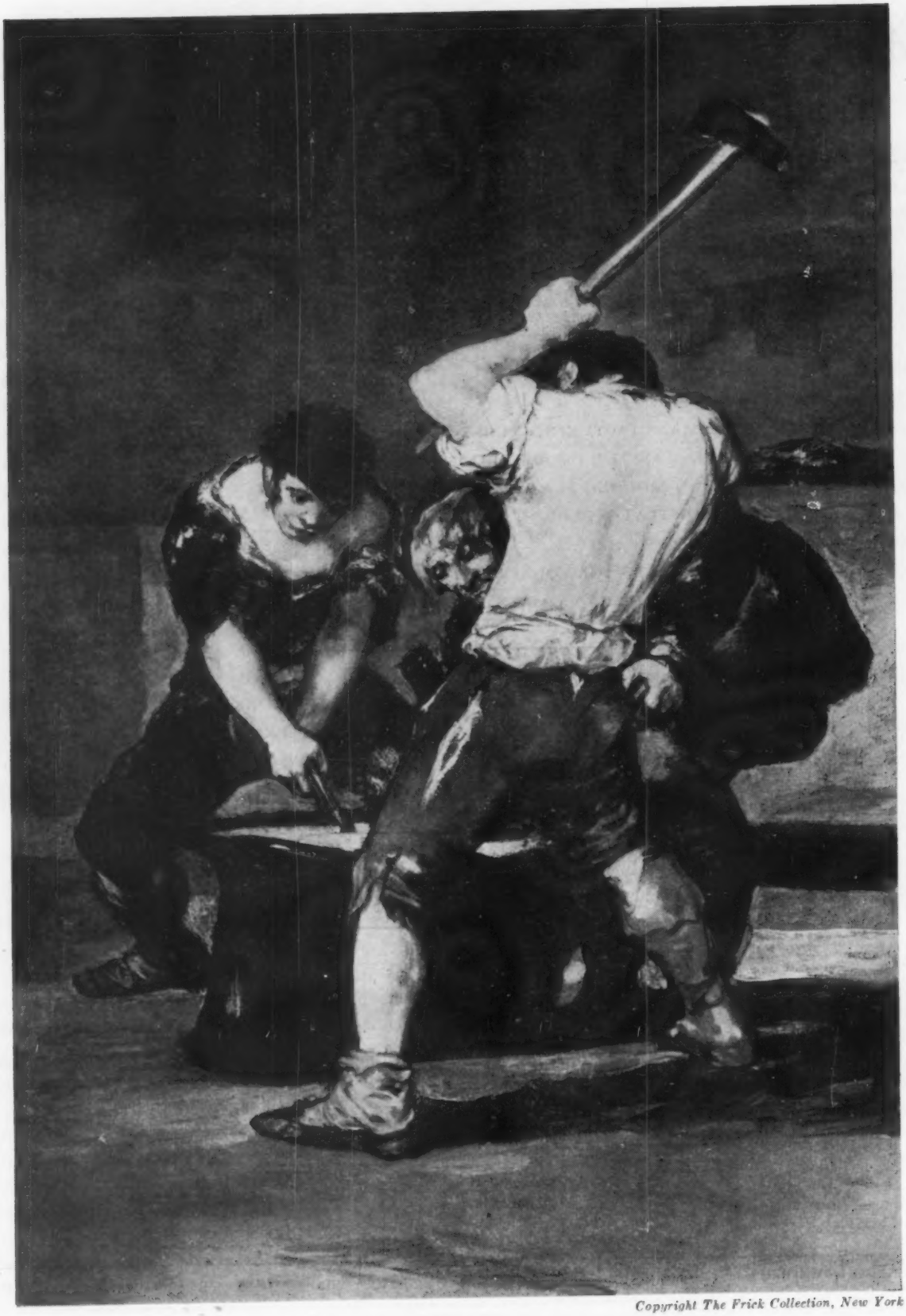

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Goya's The "Blacksmiths"

VOLUME 69
No. 6

MECHANICAL ENGINEERING

JUNE
1947

GEORGE A. STETSON, *Editor*

90-Day Rule

THE American Society of Mechanical Engineers is making a valiant effort to put into effect its so-called 90-day rule in respect to technical papers scheduled for presentation at its meetings. This rule, the substance of which is to require authors to have in completed form, 90 days in advance of a meeting, the manuscripts and illustrations of the papers they are to present, was followed with fairly satisfactory results before the war. Under the pressure of war conditions, however, it was considerably relaxed because many authors were too busy to prepare manuscripts so far in advance, because developments moved so fast during that period, and because commitments in advance were so difficult to make that many last-minute papers had to be accepted. With the return of more nearly normal conditions, many of the reasons for delay have become less compelling. Good program-making dictates a return to observance of the 90-day rule, not because adherence to it lessens the burden of planning and adds to the convenience of committee and staff duties, which of course it does, but because the members who attend Society meetings are better served.

It is the benefit to engineers who attend technical meetings and expect to get a maximum return from the time and money they spend that must be kept foremost in mind in planning meetings. Intelligent discussion of a technical paper has come to be regarded as being quite as essential to a well-conducted meeting as the paper itself. More time is devoted to such discussion than to the presentation of the paper. But unless a considerable number of persons have had an opportunity to study the paper before coming to the meeting, the most constructive discussion is likely not to be forthcoming. Hence it is essential that preprints of technical papers be prepared weeks in advance for distribution to engineers who may have valuable contributions to make in written or oral discussion. This is one reason for the 90-day rule.

Another reason for the 90-day rule is not so well known to the average member who attends meetings but is apparent when it is properly considered. A considerable number of engineers attend a meeting because certain papers in which they have a lively interest are to be presented and discussed. In order that these engineers may decide whether or not they should attend a meeting and what particular sessions are likely to be of most value to them, a fairly complete program must be published well in advance of the meeting date. MECHANICAL ENGINEERING is one important means by which preliminary programs are made public. Other technical periodicals also publish these preliminary programs in whole or in part. This advance publicity, which again is provided for the convenience of the member, must be made ready for announcement at least two months before a meeting if it is to be published in time to be of use to readers. To carry on the preliminary work of organizing a program that will be reasonably complete, to fit related papers into sessions, to schedule sessions so that no two on the same subject will be held simultaneously, to group related sessions so that they are not spread out over every day of the meeting but are concentrated in one or two days, to fit sessions into the rooms and the time periods available, and to do all this so that no changes need be made after the preliminary program has been announced, requires at least a month of consultation with the authors and committees involved. Hence, another reason for adhering to the 90-day rule is established.

There is a tendency on the part of program committees and staff members to overemphasize the importance of the 90-day rule and there is a tendency on the part of authors and persons responsible for seeing that authors deliver their manuscripts on time to look upon the 90-day rule as arbitrary and unnecessary. The decision to enforce the 90-day rule should be taken not to suit the convenience or wishes of either of these groups but on the basis of providing the best service to the greatest number of members for whose benefit meetings are held and papers are presented. There is little doubt how important skillful, accurate, long-term planning is considered by engineers who have missed a session because changes were made in time schedules after the preliminary program had been announced, or by those who have been unable to procure preprints of significant papers in time to study them before a meeting. It would be helpful to know whether the average member who attends Society meetings considers these matters important to him. Do members wish a fairly complete and wholly accurate program to be announced a month, say, in advance of a meeting? Do they wish to get preprints of technical papers several weeks before they are presented? If advance programs and preprints are important to them, the 90-day rule should be observed. Do you think the 90-day rule is justifiable?

The Story of an Engineer

IN THE 1946 Annual Report of the E.C.P.D. Committee on Professional Recognition it was written, "Where is he who will write for the multitude (about the engineer) in the pages of publications with large national circulation, e.g., *Saturday Evening Post*, *Readers' Digest*,

etc.?" The answer to this query came more quickly than had been anticipated, for in the March 15, 1947, issue of the *Post* there appeared an illustrated article, "Slide Rule Man," by Richard Thruelsen, which tells the story of Bill Swiger, Stone and Webster engineer.

Years ago, the average person was fairly well acquainted with many of the workaday routines of his fellow men. The itinerant tinsmith set up his shop in the dooryard wherever there was a kettle or an umbrella to mend. We stopped in at the cobbler's and watched him at work on his bench, using the few tools of his trade, and surrounded by the worn shoes and the mended ones tied together in pairs, and great pieces of sole leather. Village workshops had open doors and windows that invited inspection. There was a brickyard, a foundry, or a sawmill not too far away. The blacksmith's shop was as much of an institution as the movies are today, and more fascinating. A grist mill, with moss-covered wheel and dust-laden beams, could be found with little searching. And the normal activities of the farm were either the daily experiences of a strenuous but healthful way of life or became vicariously a part of our own lives by the reading of hundreds of books and stories.

Modern life affords us fewer opportunities of seeing, without making a business of it, how the other fellow does his day's work. We cannot learn how clothes are made by a visit to the local tailor for a few repairs. The garage reveals nothing of the complicated process of making an automobile. The simple machinery in the shoe-repair shop is no substitute for the highly specialized equipment of shoe manufacture. The village job shop is no counterpart of the modern mass-production factory. The harvesting of natural ice has as little in common with the manufacture of the household refrigerator as the tending of a coal-fired heater has with an up-to-date power plant. Not only the work itself but the working environment of the other fellow as well has become alien to us. We know that our own jobs have become specialized and mechanized and are only small parts of highly complicated organizations, but we seldom realize that this is true of our neighbors as well. A man tells us he is an accountant, or a lawyer, or a salesman, or an engineer, and except for having discovered the name by which his occupation is called, we have learned little. What he does, what training he had, what his responsibilities are, what satisfactions he derives from his work, what manner of life he leads, or how useful his service may be, we seldom discover.

Engineers are proud of their work and their profession. They believe that their services to their fellow men are important and significant, and that the way of life in an industrial economy is largely of their making. Many of them feel that they are misunderstood and are not appreciated. This is natural and understandable and is a point of view shared by every other group. Who is there in any organization, from head to foot, who cannot say, with some measure of truth, "But for me, this work could not go forward." And as we look closely at the work and duties of other men we are less grudging in our appreciation of the services they perform. Self-respect, pride of workmanship, human dignity, loyalty, and a devotion to duty are to be found wherever men work and in whatever they work at, once we look into their lives, try to comprehend what they are doing, and relate it to our own interests and the needs of society.

One way of helping people to understand what the other fellow is doing is by telling them about it in expository articles, in novels and stories, in the drama, and in art. The *Saturday Evening Post* article about an engineer's lifework is a good example. To say Bill Swiger is an engineer means little to anyone. One cannot fail to recognize the importance of the bridge, the dam, the skyscraper—they are too huge and too easily seen. One can readily understand that foundations for these structures are necessary and important although they are unseen. But few among laymen know of the existence of the science of soil mechanics or look upon it as a specialty to which an engineer such as Bill Swiger, may give his major attention. The story of Bill Swiger has taken thousands of laymen backstage and shown them the kind of work one engineer does. It can scarcely be doubted that because of this one brief story hundreds of these readers have felt that they have caught a glimpse of something important and that they have laid down their magazines with a new interest in engineering, a new respect for it, and a fairly clear portrait of an engineer.

As engineering becomes more and more an accustomed way of life, writers will turn to it for their stories. Once they come to understand the social significance of engineering and the qualities and motivations of engineers, novelist, and dramatists will set forth these matters for the world to see, just as they have depicted the way of life, and man's reaction to it, of the nomad, the adventurer, the tiller of the soil, the warrior, the peasant, and the country squire of former times.

Henry Ford

THE following paragraph is quoted from *The Economist* for April 12, 1947.

"We shall not, therefore, in all probability, look upon his like again. But the loneliness of his eminence only increases his stature. Ford made an age. He created modern industry. He found automobiles expensive because there were so few of them, and so few of them because they were so expensive. He made his hundreds of millions by one simple act of faith—that if he produced cars in sufficient numbers for them to be cheap, people would buy them. In economic terms, he discovered the elasticity of demand for the products of industry. In retrospect it sounds simple, just as simple as the original invention of the wheel, which exists nowhere in nature. But it was hardly less fundamental, and though the workers of Detroit and of many cities in many lands, who are tied to the assembly line, may sometimes curse his name, nevertheless, when they knock off work after their short hours and are carried by public or private transport to homes whose high standard of living rests entirely on the mass production of manufactures, they owe a tribute of respect, as he passes to his grave, to the man who made it all possible."

The LIQUID-PROPELLANT ROCKET MOTOR

By JAMES H. WYLD

REACTION MOTORS, INC., DOVER, N. J.

AT intervals in the history of transportation, certain major inventions have appeared which increased the previous speed of travel by an almost staggering amount within a few years after their introduction. The most obvious past examples of this are the locomotive and the airplane, each of which multiplied the previously existing speed record by a factor of about 5 during the first four decades of its development. In our present generation, a new vehicle has now appeared which promises a still more incredible increase in transportation velocity, as revolutionary in its possibilities and as challenging to the imagination as the locomotive and the airplane were in past generations. Reference is made, of course, to the modern high-power rocket.

The modern rocket, like the locomotive and airplane before it, is based upon the use of a fundamentally new, unconventional, light, and powerful engine. This engine is the liquid-propellant rocket motor, a device so light and powerful that it produces over half a million horsepower of useful propulsive power for an engine weight of less than a thousand pounds. It is the purpose of the present paper to give a brief survey of the history of this revolutionary new engine, the development of its operating principles, and the trends in its design in the present and future.

PAULET CREDITED WITH FIRST ROCKET MOTOR

The original source of the liquid-propellant rocket idea, like many other inventions, is still quite uncertain; but there is some evidence that the earliest practical working motor of this type was constructed about 1895 by Pedro E. Paulet, a young engineer of Peru, South America, Fig. 1. Paulet did not publish an account of his work until 1927 in an obscure news article in the Lima, Peru, "El Commercio," so that the validity of his claim may be rather doubtful; but it is interesting nevertheless, to quote Paulet's description of his motor, as abstracted by A. B. Scherschevsky.[1]

The following is a free translation:

"I made my final tests with panklastite, which the discoverer of melinite, Turpin, had just introduced. As a structural material I used vanadium steel, at that time a new metal. The rocket chamber, which was conical inside, was 10 cm high and had a 10 cm mouth diameter (thus the nozzle angle was 52 deg). As to the propellants: nitrogen peroxide, and gasoline were fed into the combustion space in the upper part of the chamber through opposed injector ports with simple check valves. The ignition was electrical by means of a spark gap half way up the rocket chamber, similar to the spark plug of present-day internal-combustion engines. In the first tests the rocket chamber was provided with long flexible tubes in the form of external rings connected to the feed lines. The rocket motor was suspended so as to slide on two vertical wires and

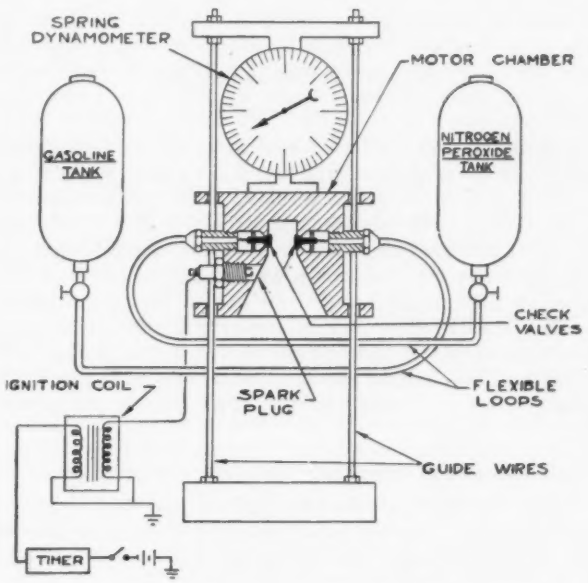

FIG. 1 PAULET MOTOR; 1895
(Schematic reconstruction from description.)

the thrust was measured by a dynamometer. The tests were very satisfactory. The rocket motor weighed 2.5 kg and gave a thrust of about 90 kg at 300 explosions per minute. The tests showed that the rocket could operate for an hour without suffering any appreciable deformation. Because of the danger involved in tests with powerful explosives and owing to other personal reasons, the tests were terminated in 1897."

Paulet's device appears to have been the earliest example of a so-called bipropellant rocket motor, in which the oxidizer and the hydrocarbon fuel are in separate tanks and are mixed only in the combustion chamber. His use of nitrogen peroxide as oxidizer also foreshadowed certain modern propellants such as nitric acid, and the setup of his test stand was quite similar to types used in later years. The intermittent fuel injection which he employed has not been commonly used in more recent motors, which almost invariably employ a constant-pressure combustion cycle.

OTHER EARLY PROPOSALS

The next definite proposal for a liquid-propellant rocket motor was in 1903 by K. E. Ziolkowsky of St. Petersburg, Russia. Ziolkowsky, a mathematics professor, published an article in the St. Petersburg *Scientific Observer*, dealing with the possibility of a rocket space ship for exploring outer space.[2] While his paper dealt mainly with the mathematical conditions for space flight (and was in fact the first really scientific at-

[1] "The Rocket for Transport and Flight," by A. B. Scherschevsky, C. J. E. Volckmann, Berlin, Germany, 1929.

Contributed by the Oil and Gas Power Division and presented at the Annual Meeting, New York, N. Y., December 2–6, 1946, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[2] "The Exploration of World Space by Reaction Apparatus," by K. E. Ziolkowsky, *Scientific Observer*, No. 5, St. Petersburg, 1903.

tempt to analyze this tantalizing problem), he also made several specific proposals for operating such a rocket, including the use of liquid oxygen and liquid hydrogen as propellants in a constant-pressure combustion chamber with a De Laval divergent expansion nozzle. This propellant combination has since received very extensive study and still remains one of the most powerful fuels so far proposed, though it has not yet been used in practical rocket work owing to various practical difficulties.

In 1913 Robert Esnault-Pelterie, an aviation pioneer who invented the familiar "joy-stick" control for airplanes, read a paper before the French Academy of Sciences on the subject of rocket space flight in which he envisaged the use of liquid rocket fuels, though still in very general terms. At about the same time Hermann Oberth, a Rumanian professor, began his early work on rocket theory, while Dr. Robert H. Goddard of Worcester, Mass., likewise began work on the problem at Clark University.

Both Oberth and Goddard were destined to play fundamental roles in the development of the new art of rocketry which as a result of their efforts began to move out of the mathematics books and into the workshop and the test field. This new period began about 1915, when Dr. Goddard started his classical experiments on the smokeless-powder rocket, which were published in 1919 in his famous Smithsonian Institution paper.[3] Unlike the early work of Ziolkowsky and others, this paper aroused much public comment and began a sort of ground swell of interest in the subject among technical men which gradually spread farther and farther, in spite of all ridicule and indifference.

GODDARD'S EXPERIMENTS WITH LIQUID PROPELLANTS

In his 1919 paper and in a 1914 patent, Goddard mentioned the possibility of using liquid propellants in rocket motors; and in 1920 he began active experimental work on the idea.

[3] "A Method of Reaching Extreme Altitudes," by R. H. Goddard, Smithsonian Institution, 1919.

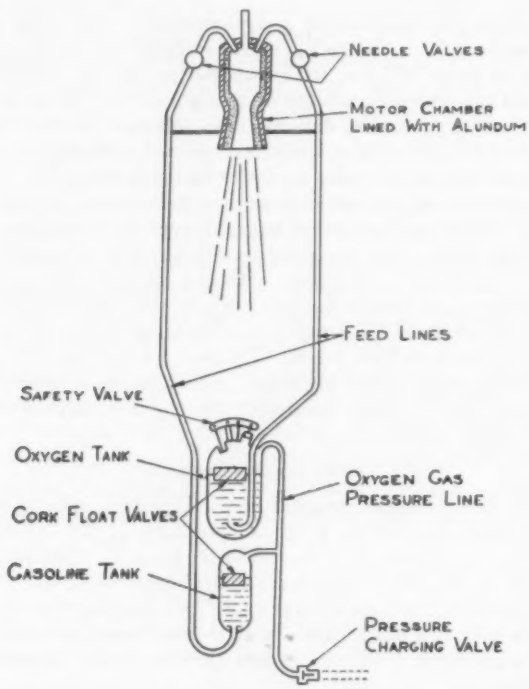

FIG. 2 GODDARD MOTOR; 1926

By 1923 he had already developed a practical liquid-oxygen-and-gasoline rocket motor, which was fed with fuel by a simple pump feed system, and on March 16, 1926, he succeeded in making a short flight of a small liquid-fuel projectile. The general arrangement of this historic machine is shown in Fig. 2, which is reproduced from G. Edward Pendray's book.[4] It will be noted that the motor of this rocket had a liner of alundum cement to protect the chamber from the intense heat.

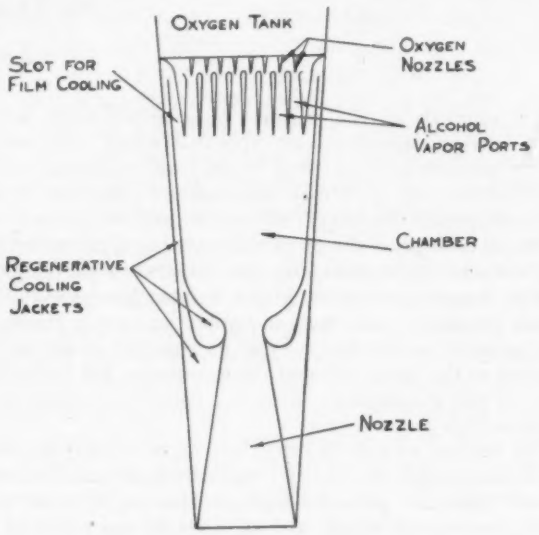

FIG. 3 OBERTH MOTOR DESIGN; 1923

This method of construction is attractively simple but has been largely abandoned in more recent designs, since it is necessary to resort to an inefficient rich fuel mixture to keep the chamber temperature down to a manageable figure.

Meanwhile, a new line of research began in Germany, following the publication, in 1923, of Hermann Oberth's book.[5] This remarkable book developed the general mathematical theory of rocket projectiles in much greater detail than any previous author, and also presented a number of strikingly advanced ideas on rocket-motor construction. Oberth proposed to use dilute ethyl alcohol and liquid oxygen as propellants, a combination which has since proved highly successful. His proposed rocket motor, shown in Fig. 3, was probably the earliest scheme involving the important regeneration principle, in which one of the propellants is circulated around the combustion chamber in a cooling jacket, thus cooling the motor and simultaneously preheating the fuel prior to its injection into the motor. He also proposed to spray part of the fuel along the inner walls of the motor to provide a boundary layer of liquid and vapor for insulating the walls from the intense heat of the flame; an early example of another important cooling method sometimes called "film cooling." His motor project also involved the use of multiple mixing parts in the motor head, each provided with concentric injection nozzles. Numerous variations of this layout have since been frequently used in large rocket motors.

ROCKET-PROPELLED AUTOMOBILE EXPERIMENTS

Oberth's treatise led to many other speculative books on the subject of rocket propulsion and its possibilities, but it was not until 1930 that any really practical results began to appear.

[4] "The Coming Age of Rocket Power," by G. Edward Pendray, Harper & Brothers, New York, N. Y., 1945.

[5] "By Rocket to Planetary Space," by Hermann Oberth, R. Oldenbourg, Munich, Germany, 1923.

In that year a rather crude liquid-propellant motor was constructed in Germany by Max Valier for use in his rocket-automobile experiments, but his work came to a rapid and tragic end when he was killed by an explosion during preliminary tests. Meanwhile, a group known as the "Society for Space Travel," which had been originally organized in 1927 by a group of amateur rocket enthusiasts, began experiments in Reineckendorf, a suburb of Berlin. During the years 1930 to 1933, they carried out a large number of tests on various simple types of liquid-propellant rocket motors and rockets, mainly under the technical direction of Rudolf Nebel and Klaus

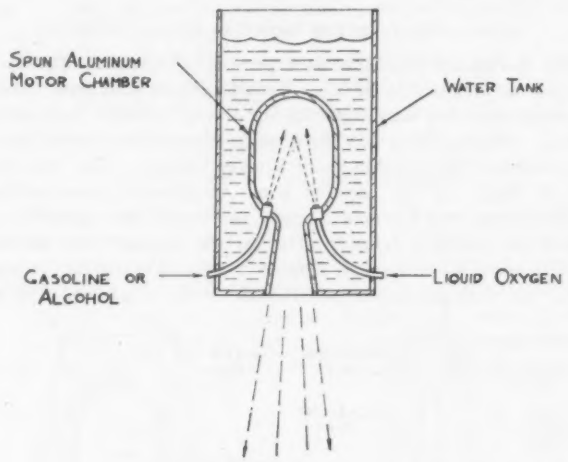

FIG. 4 SCHEMATIC OF GERMAN "REPULSOR" MOTOR; 1931

Riedel. Oberth and Johannes Winkler were also prominent in the earlier stages of this work.

The early motors of this pioneer group were rather crude affairs, but gave good enough results for short test flights. The propellants used were liquid oxygen and alcohol or liquid oxygen and gasoline. The motor construction, Fig. 4, was characterized by the use of a rather thin aluminum chamber and nozzle immersed in a small water tank for cooling, and also by "backshot" fuel injection in which the propellants were fed in close to the nozzle and sprayed toward the motor head, with a view toward improved turbulence and fuel-mixing. Neither of these features has survived in modern motors, which usually require some form of forced-circulation cooling jacket to deal with the high temperatures attained with high-efficiency combustion, and which invariably have the propellant injection ports near the head of the motor, since this is both simpler and more efficient than the older "back-shot" plan. However, these early motors of 1931 represented a first step toward the modern jacketed motor.

GERMAN ARMY TAKES OVER EXPERIMENTAL WORK

About 1933 there was a "shake-up" in the affairs of the society, and its experimental work was taken over by the German Army, and became a "top secret" military development. The tests continued at the old test field in Reineckendorf and were rapidly expanded. A young engineer named Werner Von Braun, who had assisted in the work prior to 1933, soon became prominent through his ability and energy and was put in charge of the experiments. The experimental technique was now greatly improved and progress was much faster. Experiments were made during 1934 and 1935 with the so-called A-1 and A-2 rockets. These were the first rockets with regenerative motors, cooled by their own propellants. In the case of the A-1 and A-2 motors, this was accomplished by immersing the whole rocket chamber in one of the propellant tanks, a scheme which had already been unsuccessfully tried in one of the early 1931 motors of the Society for Space Travel.

The results attained have not yet been fully revealed, but it appears that they were not fully satisfactory either as to efficiency or reliability. It became evident that a much more elaborate research project would be needed to produce a satisfactory large rocket, and in 1936 a huge new research center was set up at Peenemunde on the Baltic Sea. During the next 2 years a greatly accelerated development program was energetically pushed, which engaged a full-time staff of several hundred men. The motor development section by 1938 had produced a satisfactory regenerative motor of over 2000 lb thrust which was used to power the A-3 experimental rocket (a reduced-scale prototype of the later A-4, commonly known as the V-2).

V-2 ROCKET COMES INTO BEING

The preliminary calculations for the monster A-4 rocket date back as early as 1938, and the detailed design work on the project was begun late in 1940, the first successful flights being made in the fall of 1942. It is probable that the motor development was mostly carried out in 1941. Even at the present time the boldness of the project is startling, and it ranks second only to the American atomic bomb as the most revolutionary military development of the recent war.

It was necessary to increase the size of the previous A-3 motor, already by far the largest in the world, by a factor of about 20 to produce this gigantic new motor for the still more gigantic new rocket. The problems involved in such a project can perhaps be fully appreciated only by those who have carried out similar rocket developments under the insistent pressure of wartime conditions. It was necessary, for example, to work out fuel injectors that would properly vaporize and mix no less than 287 lb of propellants a second, to burn them efficiently in a combustion space only 3 ft long and 3 ft diam, and to keep the chamber and nozzle cool in spite of a gas blast scouring the walls at a velocity of over a mile a second and a temperature of over 3000 F. All this had to be done in a contrivance weighing only a few hundred pounds.

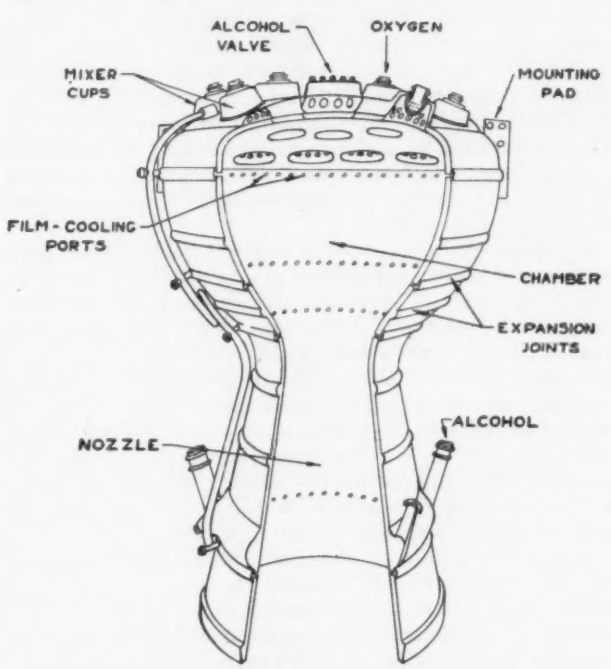

FIG. 5 A-4 MOTOR FOR V-2 ROCKET PROPULSION; 1942

DETAILS OF THE A-4 MOTOR

The end result of this remarkable feat of engineering development is shown in Fig. 5. Perhaps the most striking feature of the A-4 motor is its very lack of striking features. It is remarkably simple and logical in its general layout. The propellants used are 75 per cent ethyl alcohol and liquid oxygen, an "old reliable" fuel combination which has been used for years by other rocket experimenters. The alcohol is used to cool the motor chamber, which is of the regenerative type now in almost universal use. The alcohol coolant enters the jacket through a manifold ring around the nozzle, fed by several pipes from the alcohol pump. From there it circulates through a narrow clearance space between the jacket and the inner liner of the motor, eventually reaching a central port in the motor head which is kept closed by a large poppet valve until the motor is ready to fire. On opening the valve, the alcohol flows out into a distributing passage in the top of the head, which leads the fuel to the exterior of eighteen cup-shaped mixing chambers attached to the internal motor head; it is then injected into the interior of each cup through a series of special nozzles, producing a finely atomized spray. The liquid oxygen is fed directly from the oxygen pump to the injectors through several manifolded pipes, and is injected through a dome-shaped perforated insert in the top of each mixer cup, somewhat like a large salt shaker. The two propellants are mixed in the cups and start to burn immediately outside the cup mouths.

An interesting feature of the V-2 motor is the use of an auxiliary cooling system which injects part of the alcohol into the interior of the combustion chamber through several rings of small holes around the periphery of the motor. The fuel is injected at low velocity and spreads out on the inside wall of the chamber, forming a protective film which reduces the heat transfer from the hot gases. This expedient is an example of the film-cooling scheme mentioned earlier; in the form shown here, the idea was first carried out by Dr. R. H. Goddard in some of his early experiments of about 1930, and is described in one of his patents dated 1935.

Goddard succeeded in developing the film-cooling idea to considerable perfection, and was eventually able to operate motors as large as 1 ton thrust by this method without any cooling jackets. However, with this plan the fuel used for cooling cannot be completely burned (unlike the jacket coolant of the true regenerative motor) and this results in a reduction in efficiency; also, the size and location of the cooling holes require much laborious experimenting. Most present-day designers regard the method as a useful auxiliary to the use of cooling jackets, which can be used to clear up local overheating at certain critical points in the motor, but it is not widely used as the main cooling system.

It will be noted that the outer jacket of the V-2 motor has a number of V-shaped corrugations at intervals, which serve the purpose of expansion joints and take up the strains caused by the thermal expansion of the hot liner tube. This is apparently a minor detail, yet much difficulty has frequently occurred with certain types of rocket motor whose design had not provided for such thermal strains, and it appears that even the designers of the A-4 had considerable trouble at first with leaks and distortions caused by them. The occurrence of such strains in a motor of all-welded construction is not always at once apparent and often results in mysterious disturbances of fuel circulation and cooling which are difficult to trace.

It might be said in passing that it is just such insignificant details as this that often determine the success or failure of a motor design, and make rocket engineering as much a fine art as a science. The simplicity of a rocket motor is often highly deceptive; it is a machine in which every part is worked up to its ultimate capacity, and in which even the smallest screw or fuel port must be carefully thought out and thoroughly tested.

The mechanical construction of the A-4 motor represents the most extreme development so far made of welded sheet-metal construction in rocket motors. Except for a few of the injector parts, the entire motor is welded together from numerous pressings of low-alloy steel, most of them only $\frac{1}{8}$ in. thick. The roughly globular form of the combustion chamber, to gain additional strength and stiffness, is noteworthy. The thrust of the motor, amounting to as much as 64,000 lb, is transmitted to the rocket through only four bolts about $1\frac{1}{2}$ in. diam, attached to the outside of the motor by ball-and-socket joints.

DEVELOPMENTS OF THE AMERICAN ROCKET SOCIETY

The A-4 motor undoubtedly represents the highest development so far attained in its field; but there have been many other interesting rocket developments involving valuable new principles. Among these was the pioneer American work on rockets conducted by the American Rocket Society. This was begun in 1932, on the basis of some fragmentary information secured from the German Society for Space Travel, and continued for nearly a decade. The earliest motors built by the Society were water-cooled, similar in principle to the German ones; an example is the multinozzle motor built in 1934 by

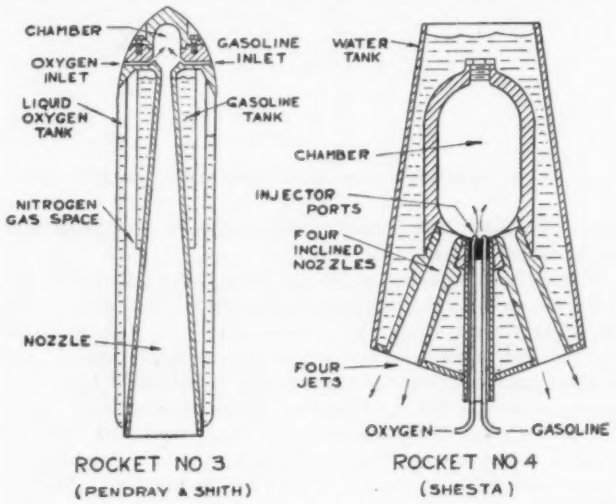

FIG. 6 TWO A.R.S. ROCKET MOTORS; 1934

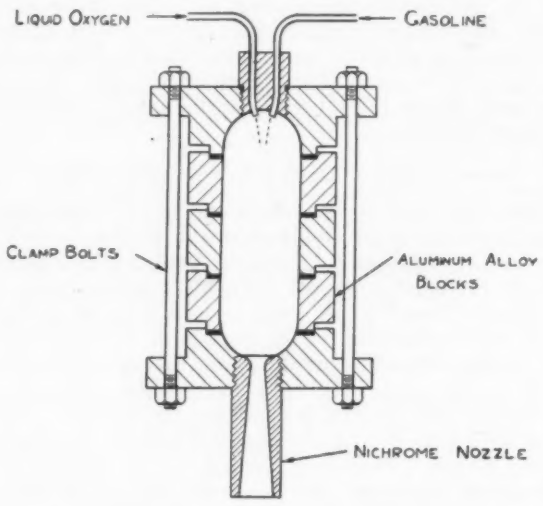

FIG. 7 A.R.S. "HEAT-SPONGE" MOTOR; 1935

John Shesta, now Research Director of Reaction Motors, Inc., Fig. 6.

Another early design of 1934, credited to G. Edward Pendray and Bernard Smith, is also shown in Fig. 6; it represents an early attempt to apply the regeneration principle to rocket motors by immersing the motor in one of the propellant tanks.

In 1935 a series of proving-stand tests were made on another type of motor, Fig. 7, involving the first application of what may be called "heat-sponge" cooling. The motor was constructed of a series of thick blocks of aluminum alloy having a high thermal conductivity; these blocks were intended to "soak up" the heat transmitted from the combustion gases and thus prevent the motor from overheating seriously during a short test run of a few seconds. This idea was only partially successful at the time but was later revised and improved in experiments at the California Institute of Technology, and has been applied to various types of short-burning solid and liquid-fuel rockets with fairly satisfactory results.

REGENERATIVE-MOTOR DEVELOPMENTS

The regenerative cooling jacket made its first appearance in practice in a small motor constructed in 1933 by Harry W. Bull of Syracuse, N. Y., a member of the American Rocket Society (see Fig. 8). Bull's motor was fired on gasoline and oxygen gas, and gave very promising results. Bull also appears to have been the first to experiment with a monopropellant-liquid-fuel motor, on which full details have unfortunately never appeared. In this type of motor, which was later extensively developed in Germany for glide-bomb propulsion and jet-assisted aircraft take-offs, the fuel and oxidizer are combined in a single propellant, which is so arranged as to burn only in the motor combustion chamber. The obvious danger in this plan is the likelihood of a flashback from the motor to the main fuel tank. The dangerous nature of monopropellants was brought home to Bull when he was seriously injured in an explosion of his motor, and he soon afterwards dropped his experiments. The scheme has been widely worked on by others in later years but has not yet attained as high a degree of safety, efficiency, or reliability as the bipropellant type, in spite of the attractive simplicity of the idea.

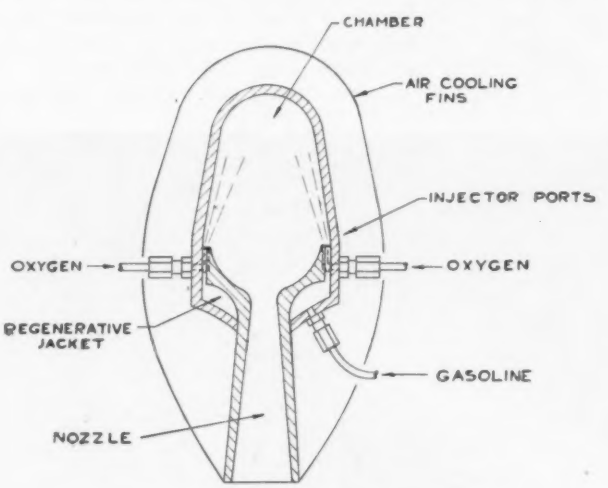

FIG. 8 BULL REGENERATIVE MOTOR; 1933

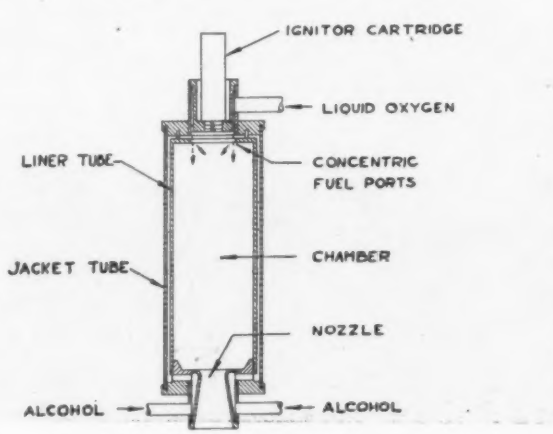

FIG. 9 WYLD MOTOR; 1938

In the same year (1933), in which Bull constructed his first regenerative motor, Eugen Saenger, an Austrian aeronautical engineer, began experiments in Vienna with a similar device. Saenger was one of the first to appreciate fully the advantages of a high chamber pressure in improving motor efficiency and jet velocity, and he claimed that his small experimental motor, operated on Diesel fuel oil and oxygen gas at about 1500 psi, attained the remarkable jet velocity of 9800 fps.

Saenger developed his ideas considerably farther during the war years, and evolved a very efficient motor of 1 ton thrust. This design was used in experiments with a novel type of rocket propellant consisting of aluminum powder suspended in fuel oil, the oxidizer being liquid oxygen. This combination seems to have been first suggested by W. Zimmermann of the American Rocket Society, about 1937; its purpose of course was to increase the jet velocity by utilizing the intense heat of burning aluminum. Saenger, however, apparently found no striking improvement over conventional fuels. He made plans for much larger types of rocket motor and even began construction of an enormous motor of 100 tons thrust; however, in the latter part of the war his work was shifted to ram-jet research, probably because of some shift in army policy on rocket development.

REACTION-MOTORS FIRM ORGANIZED

Another early regenerative motor was constructed by the author in 1938, Fig. 9. This was the first American design to apply regenerative cooling to all parts of the motor. (Bull's earlier design had used regeneration for nozzle cooling only.) The motor, first tested in 1938, proved very reliable and efficient, and after further tests in 1941, a small company, Reaction Motors, Inc., was formed by several members of the American Rocket Society to develop motors of this general type for military applications. The founders of the company, (who were Lovell Lawrence, Jr., John Shesta, H. F. Pierce, and the author), were not only the infant concern's sole officials, but also its sole employees and it may be added, its sole investors. Under a series of small research contracts from the U. S. Navy, numerous motors of rapidly increasing size were constructed. The first models, up to June, 1942, were very similar to the original design of 1938, developing only 100 lb thrust.

However, by November, 1942, successful runs were being made at over 1000 lb thrust and this was increased to 3400 lb by May, 1943, less than a year after the test work at 100-lb thrust.

This work was accomplished by a total personnel of less than twenty men, and it may be observed without undue boasting that the corresponding German development work in 1934–1938, which was only disclosed after the end of the war, had required 4 years' work by several dozen men and must have cost at least a million dollars, resulting in a motor having the same thrust as the American design, but a much poorer jet velocity. This seems a convincing proof that the lack of progress of American rocket research had not been due to any inherent lack

of technical skill, but was caused solely by the prevailing attitude of ridicule and indifference to the whole subject which blocked almost all advance for at least 10 years.

It is true that there has been a very drastic change for the better in this respect in the last year or so, and the technical public now displays an almost feverish interest in rocket developments. The author, having observed the early struggles of rocket pioneers for over a decade, will merely remark that it is about time the public "should run a fever."

MULTIPLE-CYLINDER ROCKET ENGINE FOR AIRCRAFT

Much of the most recent work in this country on liquid-propellant rockets is still confidential. However, some data have recently been released on a rocket engine built by the author's company for high-speed aircraft propulsion, Fig. 10. This engine is the first example of a multiple-cylinder rocket engine, a new principle with important future possibilities.

The 3-ton thrust of the motor is divided between four individual motor units or cylinders mounted in a close array. Each motor is provided with its own valves and igniter. Thus, by operating from one to four cylinders and simultaneously adjusting the fuel flow by throttle valves, any thrust from less than 1000 lb to over 6000 lb can be attained at high motor efficiency. This flexibility is of great importance in certain applications of rocket engines.

The present type is intended as a power plant for a recently built transonic research airplane, which will make its first flights in the near future. The motor will develop 12,000 bhp at the speed of sound (750 mph) and rated 6000 lb thrust, on an engine weight of 210 lb. The propellants used are liquid oxygen and alcohol.

Numerous other rocket-motor projects are now being carried out by various American firms and government agencies. Special mention should be made of the work being done by the California Institute of Technology and by the Aerojet Engineering Corporation of Azusa, California, founded by some of the CIT members in 1942. The best known example of their work is the "Galcit" solid fuel "jato" unit, now receiving extensive use in assisted aircraft take-off. They have also done much research on both bipropellant and monopropellant liquid-fuel rocket motors, especially in the field of jato units.

The Galcit and Aerojet groups have made extensive use of propellants based on nitric acid as the oxidizer, which has advantages over oxygen for some applications because it can be stored in tanks for much longer periods, and because it can be made self-igniting when combined with certain hydrocarbons. Similar fuels have also been used by Reaction Motors, Inc., and by many recent German experimenters. The Galcit and Aerojet liquid-fuel motors at first used a simple "heat-sponge" method of cooling, but later models have been of the regenerative type in the interests of better efficiency and longer burning time.

GERMAN HYDROGEN-PEROXIDE MOTORS

Mention should also be made of the hydrogen-peroxide motors developed in Germany by the Walter Works of Kiel, beginning about 1940. Their earlier designs were monopropellant motors, in which the energy was developed merely by the decomposition of the peroxide by a suitable catalyst; similar arrangements were later used to supply steam for operating the fuel pumps in the A-4 rocket and the Messerschmidt rocket interceptor. The main power plant of the Messerschmidt was a bipropellant motor, however, in which the peroxide was burned with a mixture of alcohol and hydrazine hydrate in

FIG. 10 RMI 1500N4C MULTIPLE-CYLINDER MOTOR

order to obtain greater energy and exhaust velocity. This fuel combination, however, proved quite tricky and dangerous in actual use, as well as expensive, and the idea has not been widely used by other designers. However, hydrogen peroxide as a monopropellant for driving auxiliaries such as pumps is still a very useful material.

The foregoing historical outline serves to give some general idea of how the rocket motor has developed to its present state, though many interesting items have been omitted for reasons of space or security. It need hardly be added that the whole story to date is only an introductory chapter to the full history of the rocket motor, which it remains for the future to write. It would indeed be hazardous to try to predict from this early chapter how the whole book will turn out; but nevertheless it is interesting to attempt a brief survey of the present trends in rocket-motor research, and to make a few guesses about its future.

TRENDS IN ROCKET-MOTOR RESEARCH

One obvious difficulty in the way of future progress is the problem of rocket-motor cooling. This has always been a persistent "headache" from rocketry's earliest days to the present, for, as fast as cooling methods have improved, the demands upon them have constantly increased. To get improved combustion and a more efficient expansion cycle, the chamber pressures are gradually being raised from the present-day figure of 200 or 300 psi, with a consequent increase in mass velocity through the nozzle as well as some increase in gas temperature. It is not unlikely that pressures of 500 to 1000 psi may soon be in use. The chamber gas temperature in present-day motors is in excess of 5000 R, with the thermometer steadily going up. The rate of heat transfer at the nozzle is already about 2,000,000 Btu per sq ft per hr, and motor designers may soon be called upon to deal with 2 or 3 times this amount. It is evident that simple plans such as "heat-sponge" blocks or heat-resistant chamber linings cannot possibly deal with such conditions, except for special conditions where the firing time is only a few seconds. The problem will be further increased if new high-energy fuels such as liquid hydrogen are resorted to in order to get higher jet velocity, a development which is probably quite close.

Some form of regenerative cooling must obviously be used. Experience indicates that it is not so much the over-all heat transfer as the presence of local "hot spots" that cause most cooling troubles, and attention must be focused on eliminating these. Such expedients as extended-surface cooling ribs, improved coolant circulation, special materials combining high thermal conductivity and strength at high temperatures, and film-cooling of danger zones, may improve matters considerably without drastic redesign. To reach still higher ratings, it may be necessary to use closed-cycle cooling jackets with special coolant fluids circulated by pump into heat exchangers where the heat absorbed can be more conveniently taken up by the propellants. Much experiment will be needed to clear up these difficult questions.

ROCKET-MOTOR STRUCTURAL PROBLEMS

The structural problems of rocket motors also become more difficult as motor sizes and pressures increase and as weight reduction becomes more important. The modern tendency is to avoid the use of heavy cast parts, bolts, flanges, and flat surfaces and to resort to more refined design using relatively thin welded sheet-metal parts with dished surfaces and ribs to gain rigidity and strength.

Extremely large motors such as the A-4 offer special difficulty because of the relatively thick wall sections, which produce a high temperature gradient in the wall. This results in increased cooling difficulties, as well as complicated thermal stress effects, which in some cases are aggravated by various elastic instability conditions, as in the case of a nozzle externally cooled by a high-pressure coolant. Some materials research is called for here; at the present time there exist materials of high conductivity but poor high-temperature strength (such as copper or aluminum alloys), and also materials of poor conductivity but high strength (such as stainless steel). However, there seems to be no convenient material combining the two qualities.

Another problem with large motors is the fact that, generally speaking, the chamber weight for a given working pressure is directly proportional to the thrust (assuming a constant ratio of chamber volume to propellant feed rate) while the nozzle weight varies as the 3/2 power of the thrust. This can easily be shown by elementary dimensional analysis. Consequently, a very large motor will have an extremely large and heavy nozzle, representing most of the motor weight. This dilemma can theoretically be solved by using a multinozzle motor with many small nozzles instead of one large one, as proposed by Oberth more than 20 years ago. In practice it appears that this leads to great difficulty with the coolant circulation.

Another plan is to use a multiple motor, with several separate cylinders, as in the RMI 1500N4C motor, Fig. 10. This results in considerable weight saving in large sizes and provides very flexible control of the thrust; it is also well adapted to rocket steering by swiveling some of the motor jets or by throttling them differentially. There is also an increase in convenience in manufacturing and testing the motors; however, there is some increase in complication and motor bulk, as well as a control problem in synchronizing the thrust of the separate cylinders. This method seems one of the most logical approaches if very large rockets, exceeding the A-4, are to be built.

RESEARCH REQUIRED IN FUEL INJECTION

The problem of fuel injection also will require much future work. Modern practice is to use much more subdivision of the injector ports than was formerly customary; early motors had only two injection orifices, one for each propellant, but it is not uncommon for modern types to have over a hundred, and the A-4 motor has a total of over three thousand. Determination of proper shapes, sizes, and positions for these ports is a very difficult and tedious task, and there is still much disagreement as to the best solution.

Many motors utilize fuel and oxidizer jets arranged in pairs, the two jets being aimed so as to strike one another at an angle to produce mixing; other motors, such as the A-4, produce a diffuse spray of each propellant, the spray particles being mixed at random; still others, such as the Walter motor, use concentric jets in which each oxidizer jet is surrounded by an annular jet of fuel, Fig. 11. All motors so far constructed employ "solid" fuel injection; but it seems possible that a form of "air" injection may eventually be used in which part of the fuel is used to produce a preliminary gas stream for vaporizing the remaining propellant.

Another injection difficulty in rocket motors is the low pressure drop in the injection nozzles, which generally does not exceed 100 psi, owing to the excessive tank or pump weight needed if high pressure is used. If the motor is throttled down to low thrust, the injection conditions become particularly bad due to the very low injector drop, and it will no doubt be necessary to resort to various variable-area injectors in certain motors where a widely varying thrust is required.

The Walter motor involved the use of a distributor valve which cut in varying numbers of injector orifices according to the required thrust; many other devices are also possible and

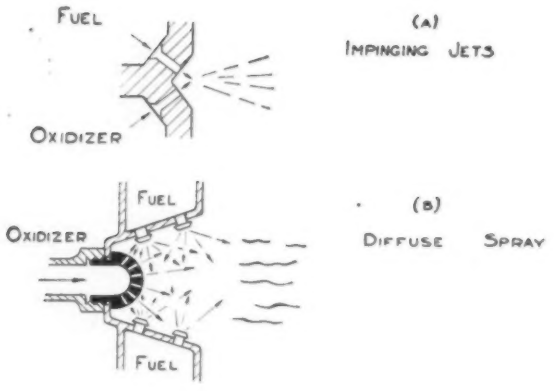

FIG. 11 TYPES OF INJECTORS

will no doubt be experimented with in the future. There is also room for much research on the interactions between injector design and the distribution of combustion zones and heated areas in the motor.

MODERN PROPELLANTS NEEDED

Finally, something should be said regarding modern propellant research and the possible output of future rocket motors. The propellants now in use with liquid oxygen, i.e., ethyl alcohol and gasoline, are essentially the same as those of 15 years ago, but the jet velocity has been raised from values of about 4000 fps at that time to about 7000 fps at present, an improvement due primarily to better fuel injection and better cooling methods, as well as to some increase in chamber pressure. By using higher chamber pressures than the present ones, it appears that velocities of about 8000 or 9000 fps should be attainable. To get appreciably beyond this, special propellants will have to be used, possibly involving the high combustion heat produced by pure hydrogen. A number of combinations of this sort have been proposed which theoretically permit exhaust velocities as high as 12,000 fps, even after allowing for the various losses involved in combustion and expansion; and some small-scale experiments have indicated that such exhaust speeds can actually be attained in practice under favorable conditions. Because of considerations of expense and various difficulties in preparing and handling them, these "superhot" propellants are only in the laboratory stage, but the future will undoubtedly see them in extended use wherever a very high degree of performance is required from a rocket motor.

In so far as thrust is concerned, there appears to be no practical limit in sight if multiple-cylinder units are used, although it does not seem feasible to construct single cylinders having much over 50 to 100 tons thrust, that is, 2 to 4 times as large as the A-4 motor, because of the rapidly increasing nozzle weight and cooling difficulties.

SPECULATION ON NUCLEAR ENERGY AS POWER SOURCE

It is still questionable whether a jet velocity of 12,000 fps will permit the construction of practical transoceanic rockets or of true spaceships attaining an orbital velocity or even a full escape velocity. To be really sure of achieving such feats, some ways must be found to utilize nuclear energy in a practical rocket motor. If this could be done with even reasonably good efficiency, all the books about jet velocity and mass ratio could be thrown out the window, for the energy available for propulsion would be so great as to render a trip to the moon no more difficult than a ferryboat ride from New York to Hoboken. However, it is as fruitless a task to try to imagine what an atomic-energy rocket motor will actually look like as it would be to make up working drawings for the *Queen Elizabeth* from the plans of a toy steamboat. Obviously, the job cannot be done simply by blowing steam or hydrogen through a high-energy nuclear pile to develop hot gas, for we then have all the present difficulties with chamber temperatures in an exaggerated form, and no real improvement in jet velocity.

On the other hand, we certainly cannot expect to let off a charge of plutonium or U-235 in a rocket chamber, unless we use a large hollow iron asteroid with a hole in one end; for the critical-mass effect makes it necessary to have either a tremendous explosion or no results at all.

It remains for us to see whether some intermediate solution will eventually be discovered. The great recent progress in rocketry and in nuclear energy leads one to think that the technical difficulties involved will certainly be solved, perhaps within one generation; but this does not remove the major obstacle to space flight, which is not technical but political, so to speak.

The development of an atomic-energy motor powerful enough to drive a true space ship presupposes the existence of high-power rockets capable of carrying atomic bombs to every corner of the earth, thus providing a means for our present technical civilization to commit suicide within a few minutes. A rocket engineer familiar with human history, if asked to predict whether rocketry will eventually lead to true space flight or whether it will lead to the complete extinguishment of all science, may well be forgiven some pessimism about the answer, and even some rather acute feelings about personal guilt. That the present-day rocket motor is only a tiny prelude to the monster engines of a future rocket age is absolutely certain; but (to borrow Thoreau's phrase of a century ago) whether we are to live like baboons or men is a little uncertain.

UP TO the present, jet propulsion has been confined almost entirely to airplanes. Now Sir Malcolm Campbell is to use a jet engine to power his redesigned *Bluebird* racing boat when he attempts to improve upon his own world's water-speed record of 141 mph. He has chosen the de Havilland Goblin engine, as fitted in the de Havilland Vampire interceptor fighter, now in service with the Royal Air Force, the Royal Navy, and the Swedish and Swiss Air Forces.

The new *Bluebird* will rely for propulsion entirely on the reaction from the jet stream, which is ejected from the back of the boat, only a few inches above the water. The power available at speed will be equivalent to an orthodox engine-and-screw installation developing 3000 hp for a power-plant weight of only 1500 lb. A saving in weight of 430 lb will result as compared with the original *Bluebird* and there is a reserve of power equivalent to several thousand more horsepower should the boat prove capable of using it.

The two air intakes are placed well forward on the top decking and, realizing that there was a possibility of water surging into them, the de Havilland engineers simulated the expected conditions by pumping a large quantity of fresh water into these intakes, with the engine running. Far from experiencing any ill-effects, the engine took this treatment in its stride and even produced more power.

INDUSTRIAL WASTE DISPOSAL

General Aspects and Trends in the Midwest

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INTRODUCTION

THIS paper outlines in simple terms the general aspects of stream pollution and domestic sewerage and sewage treatment, as background material for an understanding of the problems encountered in the handling of industrial wastes. An over-all picture is presented of the nation-wide scope of industrial waste pollution with particular emphasis on the critical situation throughout the industrial Midwest. The relative interests of the public authorities and of industry are stated. Some typical wastes are described by population equivalent or other characteristics; their deleterious character is explained; and the manner in which treatment may be effected in some typical or selected cases is given. Atmospheric pollution is not discussed. Trends in the division of responsibility and for the division of cost between industry and municipalities in the matter of handling and treating industrial wastes, are touched upon. There are some general observations on recovery aspects and on pertinent engineering matters.

The purpose of the paper is to offer some material on the matter of industrial-waste pollution for the orientation of engineers in industry. The primary technical interest of men in this category is in production. While production in many industries leads inescapably to the by-production of harmful trade wastes, the industrial engineer is not likely to be expert in disposal problems. Such problems are of a character generally extraneous to plant engineering as such. They involve physical and biochemical aspects of stream flow, and of sewerage and sewage treatment. These are environmental factors of special kind. Conformity with the covering recommendations of local or regional public authorities is necessary. Approvals are required. The problems in waste disposal or waste treatment arise in a particular industry with relative infrequency, usually as new plants are building or as some revision to current practice becomes necessary. The solution is usually delegated to sanitary engineers who can work it out with the plant engineers, and arrive at a suitable permissive arrangement with the authorities, up to or including the development of a treatment process and treatment-plant design.

Disposal problems in many localities are becoming increasingly important and pressing. As never before, the cost of waste-treatment plants and the cost of operating them may be in many instances a locality factor bearing on production costs and operating problems just as surely as any other element in manufacturing.

This paper then treats of some fundamentals on the subject of stream pollution and sewage disposal and gives some idea of the nature and extent of the problem. Attention is focused on the Midwest where large industrial operations are centered. Based on experience in this region, some examples are given to illustrate the points involved. Also, the paper touches upon some industrial practices and procedures in the engineering work necessary in industrial waste disposal.

STREAM POLLUTION

A watercourse may be used to carry away the spent water supply of a community, as sewage, only if the pollution effect of the wastes can be satisfactorily absorbed by the flow. A river is a living thing which can of itself recover from indigestion or disease if the attack is not too long and severe. A heavy pollution load will degrade the stream and interfere with its proper utilization by others, which is a violation of riparian rights under the common law.

If the stream is overburdened by wastes, it will be necessary to temper the character of the sewage by treatment. The sewage-borne solids must be extracted, and the chemical and biological character of the effluent changed to the degree which is needed for remedy. The sludge, scum, grit, and screenings removed by this treatment must be suitably prepared for satisfactory disposal as well.

Extent and Intensity of Sewage Pollution. According to the National Resources Committee (1),[2] about one half the population of the United States is serviced with sewer systems (as of 1938), and about one half of the sewage so collected is treated more or less before being discharged into the streams. The total flow in all the sewers was some 5.75 billions of gallons daily; 1.75 billions receiving complete treatment; 1.50 billions receiving primary treatment (from screening up to settling); and 2.50 billions of gallons receiving no treatment at all, being discharged raw. This means that the country as a whole is fairly well sewered, for the unsewered population is scattered through the smaller communities and rural districts which contribute little to stream pollution. However, the provisions for sewage treatment are by no means adequate.

The deficiency in sewage-treatment facilities is not immediately related to the foregoing figures, for pollution problems are a matter of local intensity and not of over-all loading. Of first importance is the fact that 75 per cent of all this sewage originates in the highly concentrated population belt of urban communities, extending from New England and the North Atlantic states westerly through the Great Lakes, Ohio River, and upper Mississippi River drainage basins. It follows that our needs for sewage and trade wastes treatment in this section of the country are most critical.

These needs may be stated in dollars as the result of a survey by the U. S. Public Health Service (2). As of 1942, the country needs as a whole: For sewers, 1.2 billions of dollars; for municipal sewage treatment, 0.7 billion; for industrial-waste treatment, 0.15 billion at municipal plants and 0.16 billion at independent plants. The needs for trade-waste treatment in the individual states included in the Midwest area are broken down as shown in Table 1.

The sum total of industrial waste pollution in the United States is estimated to be about the same as that from the raw

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[2] Numbers in parentheses refer to Bibliography at end of paper.

TABLE 1 ESTIMATED NEEDS IN INDUSTRIAL WASTE TREATMENT PLANTS IN MILLIONS OF DOLLARS

	At municipal plants	At independent plants
Illinois	10.8	11.3
Indiana	4.4	4.6
Iowa	3.5	3.7
Kentucky	2.5	2.6
Michigan	3.0	3.1
Minnesota	2.6	2.8
Ohio	7.9	8.3
Pennsylvania	17.0	18.0
West Virginia	2.4	2.5
Wisconsin	1.5	1.6

and partially treated sewage which discharges into the streams, and the two together have about the same pollution effect as the normal sewage from some 100,000,000 of persons.

BASIC CHARACTER AND BEHAVIOR OF SEWAGE

In order to understand the manner in which various trade wastes may cause trouble when discharged untreated, it is necessary to keep in mind the basic character of sewage, and the changes which take place in it as it is transported by water.

Garbage, trash, fecal matter, urine, washings, and a variety of unwanted material is flushed into the drains by the spent water supply in the form of sewage. This sewage is seeded with and offers abundant food supply for a myriad of bacteria and larger organisms which multiply in this happy environment with zest. All living things must have oxygen. Some, such as aerobic bacteria, can assimilate only free oxygen. Others, such as anaerobic bacteria, can assimilate oxygen from organic or inorganic compounds. Still others, such as facultative bacteria, can do either. Until the limited quantity of dissolved oxygen in the water supply is used up, the unstable organic matter (starches, fats, proteins, and carbohydrates) undergo biochemical alteration with the production of CO_2, H_2O, and nitrates and sulphates, which are inoffensive and stable. When, however, the free oxygen is exhausted, the aerobic organisms succumb and the anaerobic types get busy. These extract the combined oxygen from the mineral and organic compounds with the release of foul-smelling gases, such as methane, H_2S, ammonia, mercaptans, and fetid and putrid vapors. These are so-called septic conditions and may arise within the few hours required for transit of the sewage from its point of origin to its point of discharge.

Upon discharge of raw or partially treated sewage into a stream, comparable conditions obtain, altered of course by the dilution effect and the larger reservoir of free oxygen in the watercourse, and by competing organisms.

An unfouled stream is a kind of balanced aquarium, with healthy plant and animal life thriving in an environment which under normal conditions is mildly alkaline, and in which the oxygen requirements for the aquatic life are supplied as needed by absorption from the atmosphere. At normal temperatures, natural waters hold about 0.8 per cent of dissolved oxygen by volume, or 9 to 12 ppm by weight (saturation value). This is a pretty small quantity to be sure and only about $^1/_{20}$ that in the atmosphere, so that the oxygen balance is rather sensitive to any demands on it. Sewage pollution in sufficient intensity may deplete the oxygen faster than it is replenished from the air. Most fish cannot live in waters containing less than 3.5 ppm oxygen and bad conditions may obtain at or above this mark.

It is manifest that the pollution effect of sewage is related to the quantity of solids it carries, particularly the suspended solids (measured by accepted tests); and by the avidity of it for oxygen (measured by the biochemical-oxygen-demand test, or B.O.D.).

OBJECT AND METHOD IN SEWAGE TREATMENT

Clearly the object of sewage treatment, in simplest terms, is to capture the solids (by such means as screening, settling with or without coagulants, and filtration); and mechanically to furnish the oxygen needed to stabilize any organic matter in the clarified sewage. All sewage plants provide the structures and equipment for accomplishing these purposes in one degree or another.

Sewage treatment is not usually directed toward eliminating the bacteria from the plant effluent unless it is important in a particular locality to protect bathing beaches and recreation waters, or to protect waters that are used downstream for water supply. Chlorination may be practiced for this purpose to sterilize the effluent, either seasonally or around the calendar as needed.

There are approximately 6000 sewage-treatment plants around the country of one form or another all designed primarily to handle domestic sewage. If there is anything such as a "normal" or "typical" sewage, it is slightly alkaline, and carries about 250 parts per million of suspended solids, with a B.O.D. (5 day, 20° value) around 200 ppm, with a modest amount of trash (matches, rags, small debris), some fats, soaps, and oil, and grit if it is from a combined system receiving storm water.

Complete treatment for such a sewage will probably include (*a*) screening for removing trash; (*b*) primary sedimentation and skimming for removal of scum, and settling of about 50 per cent of the suspended matter; (*c*) aeration in one form or other for satisfying the B.O.D. and for coagulating for further settling; (*d*) final sedimentation for extraction of another 45 per cent of the suspended solids; and possibly (*e*) chlorination. The sludge drawn from the settling tanks will be a concentrate containing not over 2 per cent solids, about half mineral and half organic. This may be digested in closed tanks under bacteriological action, affording destruction of about one half the organic matter; and yielding gas with about the Btu content and characteristics of illuminating gas, and a concentrated and stable sludge. This digested sludge may be dewatered mechanically to give a moist sludge cake.

The end products of such treatment will be (*a*) grit, (*b*) screenings, (*c*) scum, (*d*) dried sludge, and (*e*) sludge gas; plus of course the clarified and oxidized effluent, substantially equal in volume to the sewage flow. The material taken out is disposed of in the most convenient or economical manner possible, perhaps by burning or by carting away to spoils points.

The plants which use chemicals for basic treatment are much fewer in number than those like the hypothetical one described, where the action is completely physical and biological or biochemical. It is important to remember this when considering the effect of trade wastes on the treatment processes.

The direct costs of treatment depend upon the quantity of material handled and the quantity of chemicals used in treatment. These costs are seldom offset by the money value of any of the end products from treatment; though in some plants some return (ranging from quite modest to quite important) is secured from the sale of sludge and the utilization of the gas for power.

POPULATION EQUIVALENT

From the foregoing, it follows that an industrial waste may be a problem if discharged raw, provided either (*a*) it adds to the solids or to the oxygen demand of the sewage, or both, or (*b*) it is of a nature to upset the normal processes of sewage treatment or stream purification. In any case, it burdens the sewerage facilities by adding volume and by requiring some incremental expense for treatment.

If, volume for volume, an industrial waste requires about the

same treatment and is about as strong in suspended solids and B.O.D. as a domestic sewage, and if the average quantity of domestic sewage flow is taken as 100 gal per capita per day, then an industrial waste flow averaging 100 gal per day would be said to have a population equivalent of 1. Twice the flow, or the same flow having twice the strength, would have a population equivalent of 2, etc. Here is a convenient measure by which a large class of wastes may be compared for their pollution effect. The term "population equivalent" is in common use, but unfortunately it does not cover all cases. There is no comparable "population equivalent" for solutions of high alkalinity, high acidity, high toxicity, etc., any of which may be devastating to biochemical processes.

The B.O.D. or suspended-solids population equivalent of a waste from a brewery making 500 bbl of beer per day and discharging 150,000 gal of liquid wastes having 650 ppm suspended solids and a B.O.D. of 1200 ppm is worked out as shown in Table 2.

TABLE 2 SAMPLE ESTIMATE OF POPULATION EQUIVALENT

	Analysis				Population equivalent	
	Suspended solids		B.O.D.		Suspended solids,	B.O.D.
Item	Ppm	Lb per day	Ppm	Lb per day	persons	persons
Domestic sewage 100 gal per capita	240	0.200	200	0.167	1	1
Brewery wastes 300 gal per bbl...	650	1.62	1200	3.000	8	18
Brewery producing 500 bbl per day	..	..	..	....	4000	9000

In terms of B.O.D., the brewery wastes in a plant of this size are equivalent to 9000 persons, or to a domestic-sewage flow of 900,000 gal daily, since, per barrel, the wastes are 3 times as voluminous as the sewage per capita and 6 times as strong.

Population Equivalents for Various Industrial Wastes. Based on analyses for suspended solids and B.O.D., the population equivalents of the wastes in several industries have been calculated. Average or typical values for certain localities are available from several sources. Among those published by the U. S. Public Health Service (2) are the equivalents given in Table 3.

TABLE 3 POPULATION EQUIVALENTS FOR INDUSTRIES

Type of industry	Unit of daily production	Volume of wastes, gal per unit	Population equivalent per unit: In terms of B.O.D	Population equivalent per unit: In terms of suspended solids
Brewing: Wet and de-watered grain	1 bbl beer (31 gal)	470	12–19	6–9
Canning: Apricots, asparagus, creamed corn, peaches, pears, peas, pumpkin, squash, spinach, succotash, tomatoes	100 cases No. 2 cans	2500–16000	35–800	9–440
Coke	100 tons coal coked	360000	1500	.....
Distilling: Combined wastes	1000 bu grain mashed	600000	3500	2300
Meat: Packing, slaughter-house	100 hog units of kill	160–550	18–77	6–25
Stockyards	1 acre	25000	80	180
Poultry	1000 lb live weight	2200	300	160
Milk: Cheese factory, creamery, condensery, general dairy	1000 lb raw milk and cream	110–340	6–16	4–9
Oil refining	100 bbl crude oil	77000	60	120
Paper pulp: Groundwood, soda, sulphite	1 ton dry pulp	5000–85000	16–1330	0–6100
Paper manufacture: Mill, pasteboard, strawboard, deinking	1 ton of paper	14000–83000	26–1250	220–1920
Tanning: Vegetable, chrome	100 lb raw hides	to 800	24–48	40–80
Textile: Cotton sizing, desizing, bleaching, scouring, mercerizing	1000 lb goods	60–30000	2–108	.....
Textile: Dyeing	1000 lb goods	4800–19000	41–360	.....
Rayon: Rayon manufacture	1 cord wood distilled	680000	1000	.....
Rayon goods	1000 lb goods	140–9000	35–800	130–580
Silk hosiery	1000 lb goods	13700	1180	.....
Woolen mill	1000 lb goods	70000–240000	400–1500	.....

INDUSTRIAL VERSUS DOMESTIC SEWAGE EQUIVALENTS IN INDUSTRIAL AREAS

The magnitude of the industrial-waste-pollution load has been established in several localities by surveys made at various times. The accompanying data illustrate industrial pollution as compared with domestic sewage pollution.

In the Ohio River basin, which drains some 76,000 square miles at Cincinnati, the over-all industrial-waste loading from the industrial plants, numbering about 1800 in all, has been estimated to have a sewered population equivalent of about 10,000,000 persons. Of this, about 12 per cent passes through municipal sewage-treatment plants. Some of the balance is treated at the source and the rest reaches the streams raw, either by itself or mixed with raw sewage.

The sewered industrial wastes of Cincinnati which are included in the foregoing figure, have a population equivalent of about 1,100,000 persons. Industry in Cincinnati is predominantly in the Mill Creek area, where the sewage shows (1946) a B.O.D. of some 400 ppm and suspended solids of over 300 ppm. This is in contrast to the sewage from the Little Miami and lower river districts (with less industry) where the corresponding figures are but 255 ppm and 250 ppm, respectively.

A 1930 survey of the industrial section of Buffalo, N. Y., in which the Babcock Street sewer is located, showed that the sewage had a B.O.D. of 478 ppm and suspended solids of 680 ppm.

An excellent opportunity to compare industrial with domestic sewage was afforded in the westerly sewage district of Cleveland, Ohio, in 1926, at a time when it became necessary temporarily to divert industrial flows from the stockyard area, from the main drains. Analyses of the sewage at the plant, with and without the industrial wastes, indicated that the population equivalent of the industrial wastes was about 46 per cent of the combined flow to the treatment works. The industrial loading in Cleveland is very heavy, and present estimates are that the flow of industrial wastes now draining to the Cuyahoga River from the low-level territory alongside, exceeds in volume the grand total of all sewage passing through the three sewage-treatment plants (easterly, westerly, and southerly) of the city, which handle something over 165,000,000 gal daily.

Sewage-treatment works were designed in 1927 for Akron, Ohio, with full foreknowledge of the industrial loading. There was, however, a gentleman's agreement or understanding that some of the industries would treat some of the wastes at their source, so as to reduce the solids content of the mixed flows going to the new plant. Very little of this intention material-

ized. Consequently, the sewage has been stronger than anticipated in design and has been the cause of many operating headaches at the treatment works ever since. Wastes from the rubber industries, including the synthetic-rubber plants built during the war, greatly influence the character of the mixed sewage. Analyses show high chlorides in solution, high suspended solids, and a B.O.D. somewhat higher than typical for domestic sewage. In recent years, the Akron sewage carried about 2000 ppm total solids, 300 to 400 ppm suspended solids, about 600–700 ppm chlorides, and a B.O.D. of from 200 to 250 ppm, based upon yearly averages, but varying widely. Put on a per-capita basis, the high suspended solids load is still more striking, being (1943) about 0.500 lb per capita per day or about $2\frac{1}{2}$ times a "normal" of about 0.200 lb.

Similar data are available in the literature, especially for key industrial cites such as Indianapolis, Chicago, etc., where the importance of planning for industrial waste treatment along with sewage treatment was recognized years ago.

OTHER TYPES OF INDUSTRIAL WASTES

Water-borne wastes from industry are so diverse in character that they are not readily classified in any simple way. While the "population equivalent" is a reasonably satisfactory measure of pollution effect for wastes with high B.O.D. and high suspended solids (and this is a very large coverage), it is inapplicable to a very large variety of wastes having equal or even greater importance in many instances. In this group we find substances like those included in the following list, which are perhaps most commonly encountered, although the list is by no means complete:

(*a*) *Acids*. Acids (such as pickling liquors) may coagulate or precipitate other substances, causing high turbidity or sludge deposits. Excessive acidity inhibits biological processes, and solutions of pH 6.0 or lower may damage structures and equipment by corrosion.

(*b*) *Alkalies*. Excessive alkalinity and causticity (as from textile works, laundries, tanneries, and chemical works) are antiseptic and inhibitive to sewage treatment and stream purification. Fish life is adversely affected and may succumb.

(*c*) *Oils and Greases*. Floating oil and scum are unsightly and harmful to aquatic life and waterfowl. A little bit goes a long way, as 200 gal of oil may form sleek over a square mile of water surface. Oil and grease, either free or emulsified, are difficult to oxidize, and interfere with normal oxidation of other matters.

(*d*) *Phenols*. Phenolic substances from coke ovens and chemical industries have long been a problem, owing to their high B.O.D., but more particularly to their taste-forming properties in water supplies. Chlorination of water supplies bearing phenols in even minute quantities (even one part per billion) may form chlorophenols which are unpalatable.

(*e*) *Styrene*. Styrene may be mentioned as another example, of more recent significance, of a taste former in water supplies. It is one of the two primary raw materials used in making the commonest form of synthetic rubber. Unless tremendously diluted, it imparts a vinegary or winey sweetish odor and taste to water supplies, which is expensive to remove by any known method.

(*f*) *Tanning*. Tannery effluents are an example of a class of organic wastes which not only deoxygenate streams, but diffuse inky solutions which impart highly persistent and offensive color.

(*g*) *Metals*. Heavy metals such as copper and chromium, where not recoverable from plating wastes or other sources, are toxic materials and cumulative poisons. They have been known to diminish or stop nitrification and digestion stages of sewage treatment and to kill fish.

(*h*) *Cyanides*. Cyanides in even dry low concentrations are extremely poisonous and even dangerous; they interfere with or stop biochemical processes and kill fish.

(*i*) *Brines*. Brine is the raw material for the production of a wide variety of chemicals; it is commonly used as a dispersing agent; it is a common by-product of oil production. It is harmful to agriculture, to livestock, to water supplies, and to normal fresh-water aquatic life.

These are a few of the more common elements which enter into disposal problems.

Since the "population equivalent" of wastes is attributed to B.O.D. or suspended solids, and since many classes of wastes (as described) are objectionable primarily because of their toxicity, the author has proposed that a "toxicity index" may be useful. By experiment under controlled conditions, the digestion rate of a specified sewage sludge (and, consequently, its biochemical activity) may be measured by the rate of gas production. The rate of gas production of similar sludge under the same conditions, but inoculated with various proportions of the toxic waste, may then be determined for comparison. The relative gas production may then be taken as the "toxicity index." Thus a toxicity index of 2 would indicate that the rate of gas production is one half of normal, owing to the inhibiting effect of the waste. The relative toxicity of various substances in various concentrations so determined, and tolerance limits, would be useful things to know.

TREATMENT METHODS

Substances like the foregoing when deleterious in a given situation, must be separated, reduced, neutralized, or diluted out. One generally helpful suggestion is to study the possibility of *timing* the release of such wastes. Conditions have sometimes been made satisfactory or greatly improved by controlled and uniform release (as contrasted with batch or slug dumping); or by storage and subsequent release at a time when dilution conditions are most favorable.

Some general methods of attack on the matter of treatment are of course indicated to the engineer. Acids and alkalies can be neutralized by chemical means. Oils and greases can be separated by emulsion-breaking and flotation methods. Phenols have been either destroyed by bacteriological treatment, or profitably recovered by extraction with benzol, washing with caustic, and acidification. Tannins have been recovered to give a by-product salable in boiler-feedwater treatment. Metals have been reduced and precipitated out of solution. Cyanides have been acidified and blown to the atmosphere under safe conditions of diffusion, or broken down with chlorine into harmless carbon and nitrogen compounds. Spent brines have been made to yield iodine; in one case local conditions required evaporation of the entire saline effluent as the only practical way out. In some localities, brines have been successfully pumped to deep subterranean formations.

On an industry-wide basis, some advances have been made by certain associations or groups of industries by pooling experience, underwriting research, and the publishing of manuals on approved disposal practices. Noteworthy are the several reports of the American Petroleum Institute's Committee on Disposal of Refinery Wastes; the Mellon Institute research reports for the American Iron and Steel Institute and others, on the subject of pickling liquors; and the projected research program of the National Council for Stream Improvement, Inc., recently organized by the paper industry.

On a locality basis, the Chicago Sanitary District has for many years worked with the diverse industries in its territory on a program of sewerage betterments, and has suggested and put on record many methods for the saving of materials, the recovery of by-products, and waste treatment. Much has

been done with packing-house, corn products, brewery, distillery, coke, chemical, and miscellaneous wastes. Some of the work is summarized in a recent paper (3).

The "Final Report to the Ohio River Committee, Ohio River Pollution Survey" (2) of the U. S. Public Health Service, previously cited, includes a supplement of Industrial Waste Guides, on waste disposal in brewery, cannery, coal washery, coke, cotton, distillery, meat, milk, oil, paper, and tannery industries. This series of guides, under one cover, gives the raw materials, flow sheet, and end products of each industry, the nature and strength of its wastes, and suggestions on disposal or treatment.

There are many important papers throughout the literature of sanitary, chemical, and civil engineering on the subject of industrial wastes. An outstanding single collection of papers is the "Symposium on Industrial Wastes" (4) of the Division of Industrial and Engineering Chemistry of the American Chemical Society, including one very comprehensive paper on recovery aspects (5).

As contrasted to the field of municipal sewerage, publication in the field of industrial wastes is inevitably restricted somewhat, owing to the competitive nature of private enterprises, and their reluctance at times to divulge operating problems and techniques. Also, during the war much material that would ordinarily find its way into print did not appear and some of it probably never will.

SOME ILLUSTRATIVE CASE HISTORIES

While it is important to set up general remedial measures for particular industries, one must not lose sight of the fact that the problem of waste disposal is always conditioned by local factors such as dilution opportunity, existing sewerage and sewage-treatment facilities, local hazards and exposures, and other elements in the situation differing widely with locality, even in the same industry. Also, a set pattern of treatment cannot be rigidly followed, because any industrial waste is likely to be inconstant as to volume and content, varying not only with immediate production schedules but with changing production policy. Treatment facilities must be correspondingly flexible and extendible.

A few "case histories" are briefed to show how in specific instances, some widely different situations in waste disposal have been met.

(*a*) *Oil Disposal.* An industry making machine parts used a large quantity of cutting oils which were drained to the sewer, fouling a near-by stream used for recreation purposes in a metropolitan park. On complaint of the public authorities, an oil-separation method was devised. This consisted of catching the day's spent supply, breaking the emulsion with calcium chloride in tanks with agitators, skimming the supernatant, and burning it in an incinerator.

(*b*) *Acid Removal.* An industry serviced by city sewers discharged several tons of irrecoverable spent sulphuric acid into the system; it having been agreed between the city and the industry that under controlled rates of discharge, the sewage alkalinity would neutralize the acid. This did not work out and upon the industry was placed the onus of damage to some important metal structures forming part of the system. The industry set up an automatic neutralizing plant where with the application of lime and pH control an acceptable effluent was delivered at all times.

(*c*) *Cyanides Removal.* A state refused to permit an industrial waste containing cyanides to enter a stream. The industry involved treated its cyanide wastes by three different methods at various times (depending upon concentration), including (*a*) formation of insoluble and innocuous ferri-ferrocyanide complexes by means of iron treatment; (*b*) application of sodium-acid-sulphite; and (*c*) chlorination, for high concentrations. Since this industry was in the heart of a city, disposal to atmosphere was not considered feasible or safe.

(*d*) *Metals Removal.* The digestion process of a municipal sewage-treatment plant was virtually sterilized by copper and chromium from spent pickling and plating liquors. The character of these wastes was such that the state would not permit their discharge to any stream direct. A neutralizing and metals-precipitation plant was set up, for reduction of the chromates to chromic salts, and for precipitation of all the metals with lime.

The experienced engineer will not overlook the work of fact-finding, experimentation, and design for a particular situation involved in each of these sample cases, despite the succinctness of the statements which describe them.

LEGAL ASPECTS

Where interstate commerce or navigation matters pertaining to waterways are affected, the Federal Government may exert control. In general, however, pollution alleviation is the responsibility of state government. It may be interstate by agreement between states, where the condition of a drainage basin is of mutual concern between two or more states. Individual states then have the police power to legislate controlling acts, and to delegate their enforcement to selected or newly created state agencies, such as departments of health, water resources boards, etc. Municipalities and state corporations, (such as special districts or authorities) may enact ordinances under public authority to police and control matters pertaining to the public wealth, health, and welfare; and in fact may be sued for damages if they neglect this responsibility. In turn, they may collect damages from offenders against the public or against public property.

A recent occurrence in Ohio illustrates the manner in which offenders may be penalized. This case revolves about the accidental or careless dumping of plating wastes from an industrial plant in a slug of some magnitude, into the Little Miami River near King's Mills, resulting in a catastrophic kill of fish. Setting aside the errors of newspaper publicity accompanying the event (and arising from either prejudice or enthusiasm, depending upon the point of view), the facts reported to the author by the Commissioner of Conservation and Natural Resources for the State of Ohio seem to be briefly as follows:

An estimated quantity of 194,180 fish weighing 108,625 lb, plus 400,000 minnows and countless crawfish, mussels, turtles, and bottom organisms were destroyed; the estimated value of the food and forage fish destroyed being $25,000.

The stream and its banks were surveyed. High-water marks showed that the volume of the wastes was considerable, and residual chromium, nickel, and copper were found in the waters, on the banks, and in the bottom sludge in concentrations which were unquestionably toxic. Cyanides were suspected but none were found.

The case was settled before going to court but it had been certified to the Attorney General of Ohio for the necessary legal action before the settlement was reached by conference. The industry paid to the State of Ohio $18,000 in cash and furnished 400,000 minnows for restocking, and also agreed to so modify its waste-treatment facilities that the treated wastes would satisfy the requirements of the State Health Department and the Division of Conservation and Natural Resources.

DIVIDING COSTS ON WASTE TREATMENT

It is never the policy of a state or municipality to throttle industry by undue restrictions. Industry is the source of wealth to the community. Industry is invited to locate in the community and is nurtured so that it and the population

which depends on it for livelihood may thrive. However, in general, municipalites and sanitary districts in certain localities have felt that they have gone about as far as they can in assuming the burden of sewering industry and treating industrial wastes in conjunction with domestic wastes, and there is definite trend (*a*) to charge incremental costs for sanitation to industries direct, and (*b*) to upgrade the sanitation of communities and streams.

The Chicago Sanitary District is empowered by statute (*a*) to prohibit the discharge of wastes from any industry, exceeding an average of 10,000 gal daily into the district's sewerage system, or (*b*) to permit its discharge on reasonable terms and conditions, including fair payment, and (*c*) to establish rules and regulations governing the terms and conditions, including fair charges based upon actual incremental costs incident to the handling of such wastes.

A good discussion of the problem (6) calls attention to a formula developed by the officials of the City of Buffalo, N. Y., which allows for incremental costs based on volume, suspended solids, chlorine demand, and the cost of chemicals and power, which is typical of many efforts to arrive at a solution.

Within the past few months, the City of Akron, Ohio, has passed an ordinance based primarily on existing charges for sewerage (incremental to the water bill), with additional rates taking cognizance for industrial wastes, of B.O.D., suspended solids, and pH variance from average values for the combined sewage received at the municipal sewage-treatment plant.

There is no doubt as to the general trend, as exemplified in these particular instances, and multiplied by similar efforts o numerous municipalities to divide the costs of service with industry. There is even one example, at least, of an industry whose wastes are so large in comparison with that of the adjoining city, that it has built the treatment works and takes care of the city sewage incidentally.

Where the nature of the waste does not permit its treatment together with sewage, or where it offers a special problem with respect to stream pollution, the solution of the disposal problem may be placed squarely on the industry. There is and can be no general solution to all these difficulties.

RECOVERY AND ENGINEERING ASPECTS

Ever since Victor Hugo's rhapsody in "Les Miserables" on the amount of organic wealth allowed to flow away in the sewers of Paris and his diatribe on the perfidy of man in tolerating such waste, the layman has hopefully looked to sewage treatment as a means to recapture useful by-products, such as fertilizer. The methods for sewage sludge-handling have always been aimed for profitable results, in the sense that costs are kept to a minimum, but as noted previously, there has been no "profit" in the accepted sense of the word. Even when low-grade or (as in Milwaukee) high-grade fertilizer is produced, there is still a cost to sludge-handling which is reduced but not offset by income; and it is still true that the means of disposal are selected to secure minimum net over-all expense for treatment.

Industry, if required to give more and more attention to waste treatment, will also hopefully look to the prospects of profitable by-product recovery from wastes, and has already accomplished much in this regard, for the wastes of yesterday are the by-products of tomorrow. Yet it is safer to concede that trade-waste treatment may in most cases prove to be an expense unavoidable to manufacturing, and a necessary item in the cost of production in a particular locality. It is not likely to be a deciding factor in selecting location, but it must certainly be taken into account. In general it is chargeable to local good will, to overhead, or to operating expense in one way or another.

Some final observations on engineering aspects are perhaps in order. Present practice in the handling of domestic sewage involves the application of a variety of established treatment methods, and there are no startling developments in view though modifications may be in order. The aim of all project studies and design is engineering economy, and the spending of (generally) public money so that a local situation is met with best adaptations of accepted practice.

In contrast, industrial waste treatment experience is relatively meager, the diversity of problems is infinitely greater, and as has been pointed out, to design for the necessary operating ranges is a much more difficult problem. Consulting engineers and engineering organizations can and do design domestic sewage plants sometimes without very much preliminary experimentation or laboratory work. It is somewhat risky and frequently impossible to design industrial waste treatment plants without some research and pilot work, all of which adds to the time and cost devoted to the work.

There are two tendencies or attitudes in industry, not so commonly encountered in public work. One is the tendency to buy a solution to the problem ready made, provided a guarantee on performance goes along with it. Engineering opinions and services are purchased along with equipment that is tied up with some process which is the crux of the matter. A word of caution is in order. Promoters step in where experienced men fear to tread, and all such proposals should be impartially reviewed. The choice and risk of doing otherwise is of course optional with industry. Parenthetically, this is no disparagement of the splendid and recognized development work that is carried out by equipment manufacturers and the producers of chemicals in many fields of work, from all of which we profit in the long run, one way or another. Another tendency (and a very proper one) is that of cutting installations to bare minimum cost, sometimes at the risk of reduced tankage, pumpage, chemical storage, and handling, etc., so as to invite operating difficulties owing to lack of flexibility and necessary stand-by capacity. But industry defeats its own ends if this is carried too far. After all, the only solution to these matters lies in the employment of competent and experienced engineers, and in a meeting of minds of the industry, its engineers, and the public authorities concerned.

In conclusion, it is pertinent to remark that experience in the handling of industrial waste problems teaches a certain amount of modesty, for the range of unsolved problems is as yet very large. Much fact-finding, research, experimentation, and operating experience will be necessary before we can solve the industrial waste treatment problems that lie ahead. To those most familar with waste disposal problems, some of the author's statements may appear to oversimplify some phases of the work. In the interest of clarity and brevity, some of this appears to be necessary.

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EXTRUSION METHOD *of* MANUFACTURING TUBES

Process as Used for Tubes of Stainless Steel, Special Steel, Nickel, Monel, and Inconel

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THE extrusion method, well known for a rather long time in its application for nonferrous metals and alloys as copper, aluminum, magnesium and its alloys, has only lately been developed for dealing with stainless steel, special steel, and nickel alloys. These materials have to be extruded at high temperatures up to 2400 F, and require fast-working presses and high-quality wear- and heat-resisting tools. This explains why manufacturers have been reluctant to adopt this well-approved method for forming high-temperature ferrous and nickel alloys.

A start was made in 1926, when cupronickel was found to be an excellent material for condenser tubes. Such tubes were originally made from hollow cast billets which were reduced to final size by a considerable number of cold-drawing operations with many annealings between. This method proved to be very expensive, and a great percentage of the finished tubes had to be rejected because of porosities originating in the cast starting billet. When the British Navy favored and approved the use of cupronickel tubes, the metal industry was forced to try other methods, and it did not take long before extrusion presses up to 1000 tons capacity turned out first-class tubes in this material. Cupronickel contains 15 to 30 per cent nickel, the remainder being copper. The extrusion temperature for the 70/30 alloy is as high as 1900 F. The tools which were in contact with the hot metal such as dies, mandrels, dummy blocks, and container liners had to be made from heat- and wear-resisting steel which, at that time, had not yet been developed for such high billet temperatures. However, it did not take long before this problem was solved. According to the size of presses which are used today and which range between 600 to 2500 tons capacity, billets of 4 to 8 in. diam are used and are being commercially extruded into tubes of $1^3/_4$ in. to $3^1/_2$ in. OD with wall thicknesses of 0.16 to 0.375 in.

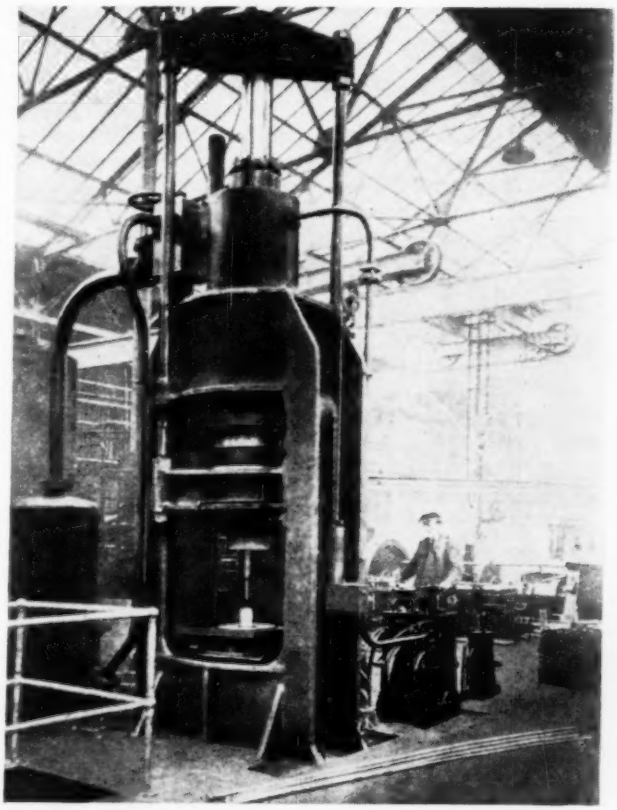


FIG. 1 EXTRUSION PRESS OF 600 TONS CAPACITY

EXTRUSION METHOD DEVELOPED FOR HIGH-TEMPERATURE METALS

The next step in the application of the extrusion method for high-temperature metals and alloys took place in 1928, when a 660-ton vertical extrusion press started operation in one of the plants of the International Nickel Company, Fig. 1. This installation has since extruded tubes in stainless steel, special steel, monel, inconel, and nickel in sizes ranging between $1^1/_2$ in. to $2^3/_8$ in. OD with walls of 0.16 to 0.25 in. The billets were preheated in some cases to a temperature of 2300 F.

Fig. 2 shows the billets as they are being preheated and extruded with this first installation. Originating from rolled or forged round bars, the billets were machined and drilled which proved to be very expensive and required a large number of machine tools. Fig. 3 shows the arrangement of the tools incorporating dies and stem heads with matching tapers of 25 deg. This design permits the metal to flow until the distance between these two tools amounts to only $^1/_8$ in. or less, resulting in a correspondingly thin unextruded portion of the billet material.

The materials extruded into tubes have the analyses given in Table 1.

Due to the high temperature employed, the metal has a tendency to become welded with the tools which makes it necessary to apply a heavy grease to those surfaces which come into contact with the hot metal. Owing to the heat accumulated in these tools, the grease burns and produces a gas and graphite

Contributed by the Metals Engineering Division for presentation at the Semi-Annual Meeting, Chicago, Ill., June 16–19, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

film which forms some kind of insulation and, at the same time, reduces the friction between the sliding hot metal and the surfaces of the tools.

The tubes so obtained were of far better quality than those previously made on a piercing mill; also the structure was more uniform which facilitated considerably the cold-drawing operations which followed.

In order to eliminate drilling the billets, which was very expensive, it was suggested that the outer surface of the billets be machined after hot-piercing. Although this made machining cheaper and reduced the loss of machining scrap,

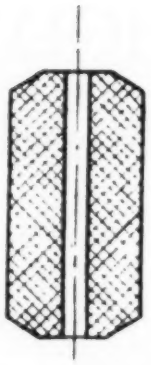


FIG. 2 BILLET

TABLE 1 ANALYSES OF EXTRUDED MATERIALS

Stainless Steel			
Ni	Cr	Wo	Ti
8	18	...	...
9	15	...	...
10	25	...	...
12	12	...	...
40	...	...	...
...	14	...	...
...	28	...	...
8	18	1	1

Nickel and Nickel Alloys								
	Ni	Cp				Fe	Cu	Mn
Nickel	99.4	...	...	...	...	...	...	...
Monel	67	...	...	...	...	1.4	29	1.0
Inconel	79.5	13	...	...	...	6.5	...	...
Heat-resisting material	80	20	...	...	...	...	...	...

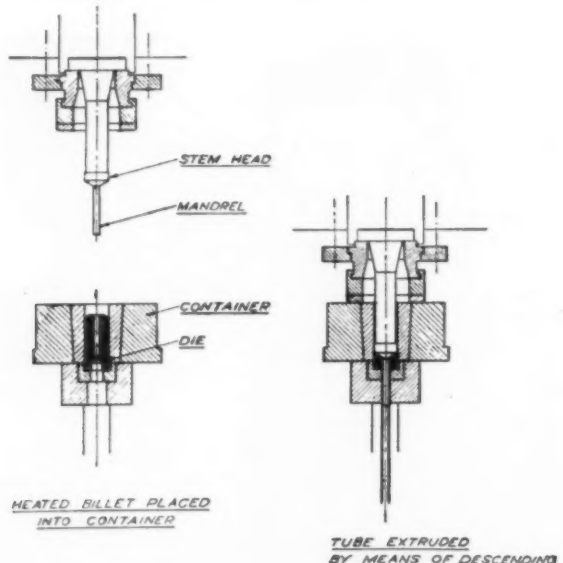


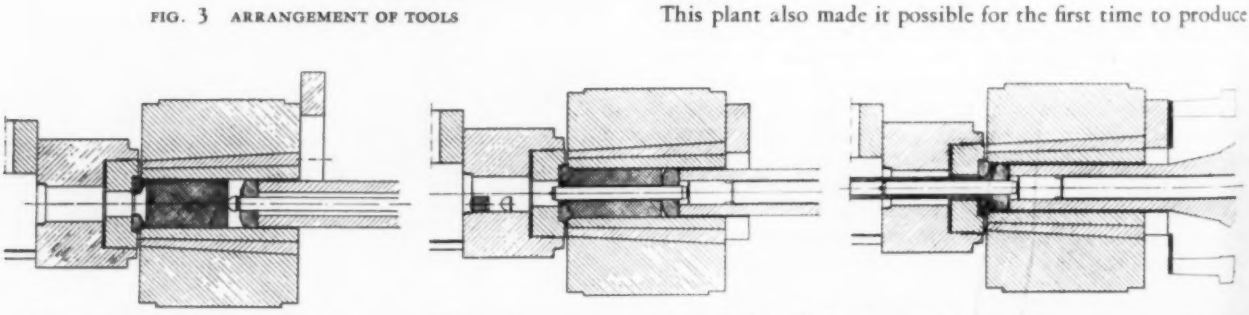
FIG. 3 ARRANGEMENT OF TOOLS

These horizontal presses of the double-acting type made it possible to extrude solid billets into tubes in one operation. To prevent the metal from getting welded onto the mandrel, a loose head placed on the mandrel point is being used. This head pierces a slightly larger hole in the billet than the inside diameter of the tube, allowing the mandrel to enter the pierced billet without stripping off the lubricant. The loose head drops from the mandrel just behind the die, together with the piercing discard. Fig. 4 shows the tool arrangement employed.

DOUBLE-ACTING PRESS USED

In this country considerable development took place when the International Nickel Company started a 4000-ton double acting press during 1943 at its plant in Huntington, West Va., Figs. 5 and 6. Since then this press has been used to extrude billets of 7 to 12 in. diam into tubes of 3 in. to 8 in. OD. Although normally monel, inconel, and nickel are extruded, many trials have been made with stainless steel and also with special steel billets, some consisting of materials which were difficult to transform into tubes by any other known method.

This plant also made it possible for the first time to produce



(*a*) Billet is inserted in container (*b*) Mandrel advances and pierces billet (*c*) Press stem and mandrel advance and extrude billet

FIG. 4 EXTRUSION OF TUBES

it was necessary to heat the billets a second time for the extrusion proper, so that the savings were negligible.

After this pioneer installation showed the way and pointed out the possibilities in the extrusion application for high-temperature metals and alloys, various larger presses of the horizontal type were installed, long before World War II, in England, France, and Czechoslovakia. It may be of particular interest to American metallurgists to learn that one of these installations extruded cast billets in stainless steel 18/8 with very good results.

economically large-sized tubes from solid billets by using the so-called cupping method. Whereas during piercing of the billet the die is normally open, in the new method the die is closed so that the metal backfills the container, Fig. 7. Only a thin disk of metal is left between the mandrel head and the closing plate, and this is punched through the die by means of the advancing mandrel after the closing plate has been removed.

When piercing billets with the die open and employing a rather large mandrel, the piercing scrap can amount up to 50

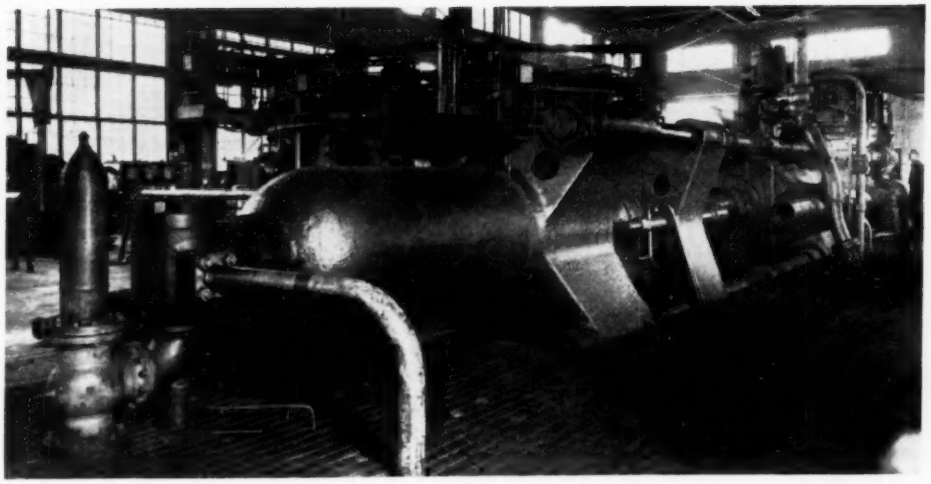


FIG. 5 EXTRUSION PRESS OF 4000 TONS CAPACITY

per cent of the billet weight, but with the method described this loss in scrap can be reduced to about 4 per cent. Tubes up to 9 in. OD in gilding metal and up to 8 in. OD in monel metal have been produced in large quantities. Since stainless steel and monel are extruded at about the same temperatures and behave similarly during extrusion, it is evident that this new method is quite suitable for the manufacture of large tubes in stainless steel.

FUNDAMENTAL PRINCIPLES FOR FURTHER EXTENSION DEVELOPMENTS

The experience gained from these existing installations points the way for further developments and shows the following fundamental principles which must be considered:

Preheating Furnace. The machined billets must be heated in a controlled atmosphere for keeping the formation of scale as small as possible. This scale is very hard and brittle and produces considerable wear on the die. Descaling of the billets by means of high-pressure water has not been done so far but it seems that this method of scale removal will go a long way toward solving the problem.

It has also been suggested to heat the billets in a salt bath which of course prevents the formation of scale entirely but, at present no experience is available, and this method has not yet been tried out on a production scale.

A uniform and precise temperature of the billets is of greatest importance for obtaining the lowest extrusion resistance and, in the case of tubes, also a good concentricity.

It has been found that various kinds of stainless steel lose their plasticity after the metal has been subjected to the final temperature for a long time. Such billets could not be extruded and had to be removed from the furnace for cooling down and then preheated a second time. Apparently, when this material is subjected for too long a time to a high temperature, a recrystallization takes place accompanied by an increase in internal friction to such an extent that the plasticity disappears. This makes it advisable, in some cases, to hold a limited number of billets only for a short time in the high-temperature zone of the furnace after they have been soaked at 1500 F, for 1 hr or more depending upon the billet size.

Extrusion Speed. Rapid extrusion is necessary to prevent cooling down of the outer billet surface which contacts the container bore. Although the container is preheated to about 600 F, the difference in temperature is still considerable. With

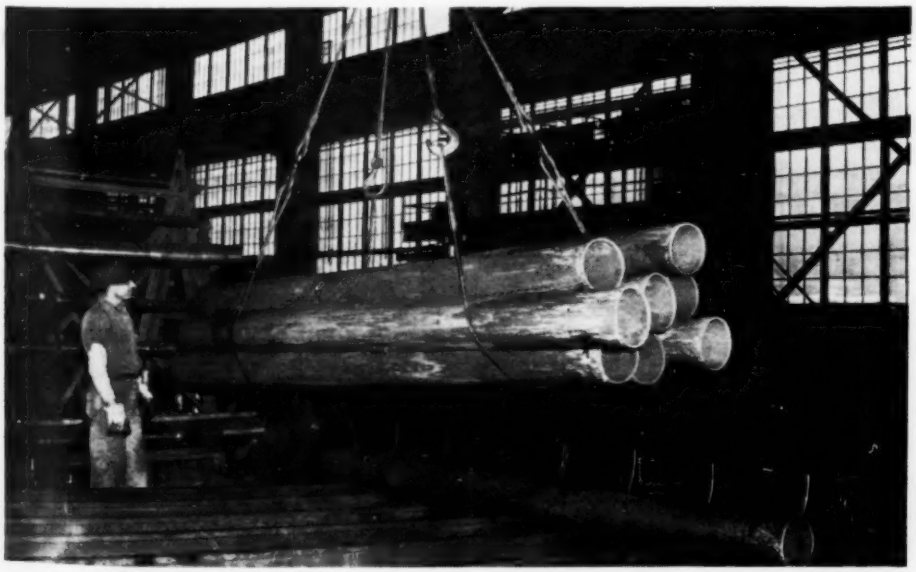
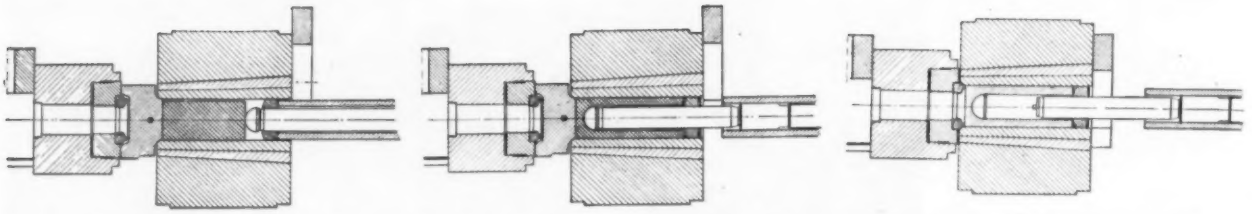


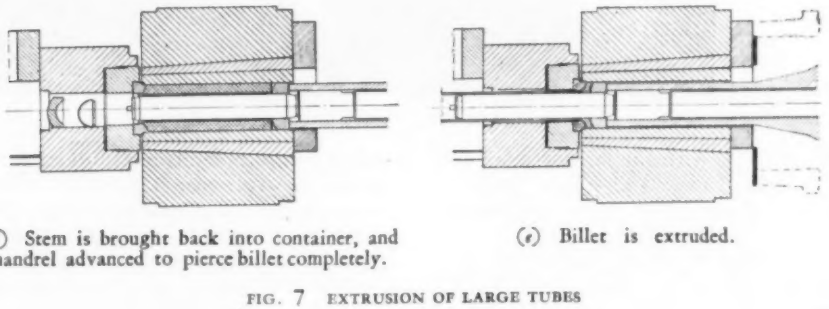
FIG. 6 EXTRUDED MONEL TUBES OF 8 IN. DIAM



(*a*) With closing plate in position, billet is brought into container.

(*b*) Pressing stem is withdrawn to allow for backflow of billet. Mandrel is advanced with pressure water until billet is almost pierced.

(*c*) Mandrel is withdrawn, container shifted, closing plate lifted, and container moved into extrusion position.



(*d*) Stem is brought back into container, and mandrel advanced to pierce billet completely.

(*e*) Billet is extruded.

FIG. 7 EXTRUSION OF LARGE TUBES

a fast-working press, the extruded products emerge from the die with the same temperature as the heated billets. Ram speeds of 4 to 6 ips, resulting in extrusion speeds of 80 to 150 ips have been obtained. After the heated billets are charged into the container, it should take only a few seconds for the conversion into a tube or rod.

Billet Sizes. The pressure on the billet for rapid extrusion must be 100,000 to 120,000 psi, in the case of tubes, with walls of $^1/_4$ to $^1/_2$ in. and an extrusion ratio of 1:20 to 1:25. The extrusion ratio is the relation between the area of the extruded product and the cross-sectional area of the billet. In case of stainless steel 18/8 and monel, a ratio of 1:25 is the maximum for an economical production.

According to experience, the billet length should not exceed twice its diameter because the extrusion resistance increases considerably with an increase above this proportion. Another limiting factor is the length of the extruded tubes, owing to the lubricant between the hot metal and the die surface being used up gradually with the increase of metal passing through the die, resulting in a considerable die wear. There is no known way to control this lubrication or insulation of the die surface at the present time, and therefore a 20-ft-long extruded tube or rod must be considered as a maximum for economical reasons. It may be mentioned that a billet of a given diameter can be transformed into only one ideal tube size; that is, from the point of view of smallest extrusion resistance, easiest flow of metal, smallest wear on the tools, and good concentricity. A good figure for the proportion between billet diameter and inside diameter of the extruded tube is 3 to 1, according to experience with various high-temperature metals.

Tools. In this discussion, tools are understood to consist of dies, mandrels, dummy blocks, and container liners. The dies are subjected to a great deal of punishment because of the high pressure exerted by the white-hot metal while sliding over their surfaces. Chromium-tungsten hot-working steel with 9 to 15 per cent tungsten has been used to a great extent, also cast and heat-treated material of the low-alloyed chromium-molybdenum-tungsten type.

For mandrels, dummy blocks, and container liners, a 9 per cent tungsten-chromium steel has proved to be satisfactory.

After each cycle, the mandrel must be cooled, either by means of oil or air. In case of large mandrels, very promising trials have been made with internal continuous water cooling. All other tools do not require any particular cooling but, for fast production, air-cooling of dies and container liners may become necessary.

In the United States, the only plant which as yet has extruded high-temperature materials is that of the International Nickel Company. Hence developments in tool materials for this purpose have been rather slow. Manufacturers of hot-working steel for tools would be given additional incentive for developments and improvements if the extrusion method should be adopted by the steel industry.

ADVANTAGES OF THE EXTRUSION METHOD

The conversion of a solid billet into a tube by the extrusion method consumes only a few seconds, during which time no change in temperature takes place. There are a considerable number of special alloys which can only be hot-worked within a very narrow temperature range, and it is in this field that extrusion must step in. There are other special steel alloys which crack when being worked in a piercing mill owing to the destruction of the fiber structure, and here also the extrusion method may be the answer. Whenever a high-quality tube with perfect internal surface and first-class structure is required, the extrusion method must be considered.

Although the manufacture of tubes has been the principal item under discussion in this paper, yet it may well be added that round and hexagonal bars and as well as simple profiles can be produced. Depending upon further progress with die materials, it may not be long before structural profiles in stainless steel will be made by the extrusion process, which is already so well known and applied in the light-metal and brass industries.

The MODERN GAS TURBINE *in the* INDUSTRIAL POWER PLANT

By J. R. HASKIN, JR.

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DURING the last few years considerable data for modern gas turbines have been published; and the use of such turbines in central-station, marine, and locomotive installations has been discussed. On the other hand, very little has been published on the possible use of gas turbines in industrial power plants. While this paper does not pretend to be an exhaustive study of such application, it is believed that it does show that the use of gas turbines in industrial power plants should receive more attention.

For the purpose of this discussion, an industrial power plant is considered to be one which is an integral part of an industrial establishment. As such, it furnishes both steam and electric power for factory processes within the establishment. Up to the present time, much, or all, of the power generated in industrial power plants has been by-product power; that is, factory power demands have been met by power generated with back-pressure or extracting-condensing turbines. This is a very efficient and economical method of power generation provided little or no power must be generated by condensing operation.

However, for a number of years, there has been a trend in some industries toward the greater use of power and the lesser use of steam in the factory. As a result of this trend, establishments which in the past have been able to meet the factory power demands with by-product power now find that they must generate some condensing power. Likewise, establishments which have been able to meet their factory power demands by generating a large percentage of their requirements as by-product power and a small percentage of their requirements as condensing power, now find that the percentage which must be met with condensing power is continually increasing. It is in this type of situation—that is, where the factory steam demands are not great enough to enable the generation of the entire factory power demand as by-product power—that the use of gas turbines should prove to be most advantageous. This is the premise that prompted the following discussion.

WHAT IS A GAS-TURBINE INDUSTRIAL POWER PLANT?

Before it is possible to discuss a gas-turbine industrial power plant, it is necessary to define such a plant. A "basic" gas-turbine plant is considered to consist of a turbine, a compressor, a generator, a waste-heat boiler and economizer, a fuel system for gas or oil, a turbine combustion chamber, a boiler combustion chamber, a feedwater system, and a reducing valve for reducing steam from main-header pressure to deaerating-heater pressure. The turbine is considered to be limited to an inlet temperature of 1200 F. The economizer should have sufficient surface to reduce the stack-gas temperature to 350 F when the feedwater temperature is 220 F. This low stack temperature is safe because of the extremely low percentage of moisture in the products of combustion. The feedwater system consists of a deaerating heater with vent condenser and a steam-turbine-driven feed pump. The deaerator is assumed to operate at approximately 17.2 psia, 220 F. The feed-pump turbine exhausts at back pressure to the deaerating heater. If there is insufficient feed-pump-turbine exhaust to heat the feedwater to 220 F, additional steam will be obtained through the reducing valve. It will be noted that in the basic gas-turbine plant no provision is made for compressor interstage cooling, turbine interstage reheating, regeneration, or multiple-turbine shafting.

Theoretically, the useful work output of a gas turbine may be controlled either by controlling the turbine-inlet temperature while maintaining the volume of air entering the compressor constant, by controlling the volume of air entering the compressor while maintaining the turbine-inlet temperature constant, or by controlling both the turbine-inlet temperature and the volume of air entering the compressor. But design limitations and practical considerations limit the method of control of the "basic" gas turbine to that of controlling the turbine-inlet temperature while maintaining the volume of air entering the compressor constant.

GAS-TURBINE EFFICIENCY

Much of the recent literature indicates that the turbine section of a gas turbine will have an efficiency of approximately 86 per cent when the turbine-inlet temperature is 1200 F, and that the compressor section of a gas turbine will have an efficiency of approximately 84 per cent when the atmospheric temperature is 70 F. While no data have been noted showing the effect variations in turbine-inlet temperature will have on the turbine efficiency, it is reasonable to expect that as the temperature is lowered the turbine efficiency will become less. Therefore let us assume the following

Turbine-inlet temperature, F	Turbine efficiency, per cent
1200	86.0
1100	84.6
990	83.0
880	81.4
785	80.3

Having made the foregoing assumptions for turbine efficiency, we should make similiar assumptions for compressor efficiency. But the range of atmospheric temperature variation will be small compared to the range of turbine-inlet-temperature variation. Therefore it is believed that a compressor efficiency of 84 per cent can be assumed for all atmospheric temperatures.

In addition to the assumptions stated, let us assume that the pressure at the compressor inlet (atmospheric pressure) is 14.7 psia, that the compressor discharge pressure is 73.5 psia, that there is a 2-psi drop between the compressor discharge and the turbine inlet, and that the turbine-exhaust pressure is 16.7 psia. With the turbine exhausting at a pressure of 2 psi above

Contributed by the Oil and Gas Power Division for presentation at the Semi-Annual Meeting, Chicago, Ill., June 16–19, 1947, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

atmospheric, it is believed that there is sufficient pressure to overcome the resistance to gas flow in the boiler and that no draft fans are required. Let us also assume that the heat content of the fuel is 18,600 Btu per lb. The data for the curves in Figs. 1, 2, and 3 were calculated using the tables prepared by Keenan and Kaye[1] and the foregoing assumptions.

It should be noted that the term "1000 lb air" common to all three figures means thousands of pounds of free air at the compressor inlet. Furthermore, the term "heat available for power generation" in Fig. 1, is actually the heat equivalent of work available, or required, for power generation with various turbine-inlet and atmospheric temperatures. Since variations in atmospheric temperature have considerable effect upon the power generated and fuel consumed by a gas turbine, data for three different atmospheric temperatures have been presented in Figs. 1 and 3. On the other hand, variations in atmospheric temperature have little effect on the heat in the gas exhausted by the turbine. Therefore data for 60 F atmospheric temperature only have been presented in Fig. 2.

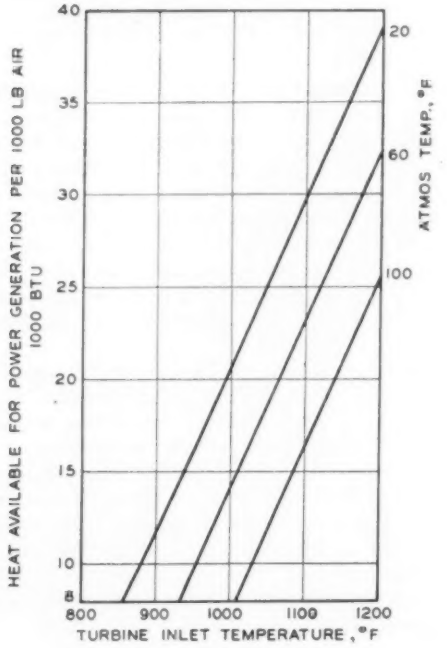

FIG. 1

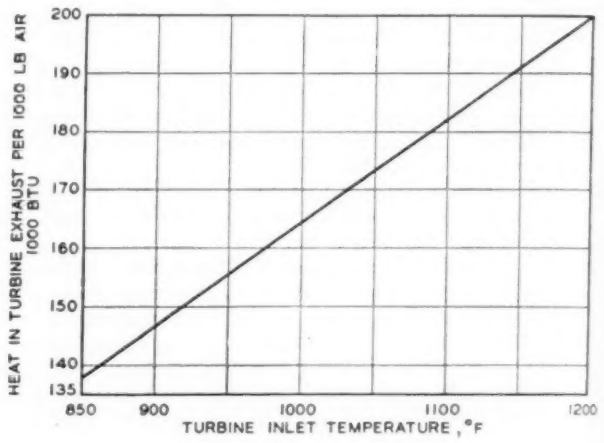

FIG. 2

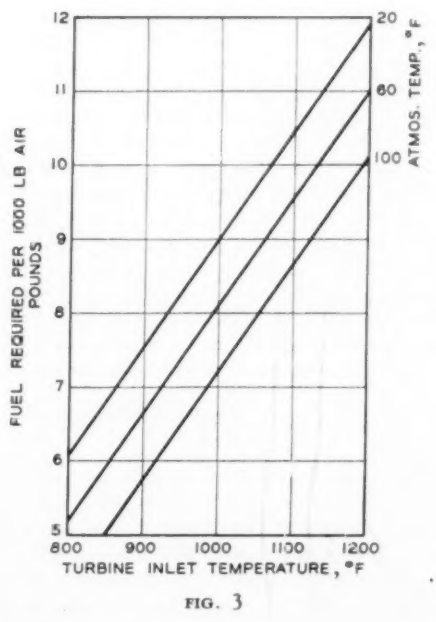

FIG. 3

ESTIMATE OF PERFORMANCE

Subject to the limitations imposed by the assumptions made, the data presented in Figs. 1, 2, and 3 can be used to estimate the performance of any basic gas-turbine power plant. For example, let us consider an industrial power plant to be situated in a locality where the maximum atmospheric temperature may reach but not exceed 100 F, and where the annual average temperature is 60 F. This plant is to be capable of generating 5000 kwhr at 80 per cent power factor at all times, but the annual average power demand by the factory is 4000 kwhr. The annual average factory steam demand is 50,000 lb per hr of 150-psi saturated-temperature steam or its equivalent in superheated steam at 150 psi.

Let us consider a basic gas-turbine plant (turbine, compressor, and generator on the same shaft; waste-heat boiler; fuel system; turbine and boiler combustion chambers; feedwater system) for this service. In such a plant, approximately 16 per cent of the steam generated will be required for the feed pump and for heating feedwater. Therefore with an annual average factory demand of 50,000 lb per hr, approximately 59,500 lb per hr must be generated. As for the power to be generated, let us assume that no power is required in the plant and that the power to be generated is the annual average factory demand of 4000 kwhr.

Since the maximum power generation of 5000 kwhr may be required when the atmospheric temperature is 100 F, we enter Fig. 1 with 100 F atmospheric temperature and 1200 F turbine-inlet temperature and find that 25,300 Btu are available for power generation per 1000 lb of air. If we assume the generator to be 97 per cent efficient at full load, 17,600,000 Btu are needed to generate 5000 kwhr, and an air flow of 690,000 lb of air per hr is required. *Since the flow of air in our basic gas turbine is to be held constant, this weight of air will pass through the turbine for all power loads.*

But our annual average power generation is only 4000 kwhr. Since this is a partial generator load, let us assume that the generator efficiency will be only 96.5 per cent. The total heat required for power generation will then be 14,100,000 Btu

[1] "Thermodynamic Properties of Air," by J. H. Keenan and J. Kaye, John Wiley and Sons, Inc., New York, N. Y., 1945.

per hr, and the heat required per 1000 lb of air will be 20,400 Btu. Then, since the average atmospheric temperature will be 60 F, we enter Fig. 1 with 20,400 Btu per 1000 lb and 60 F atmospheric temperature and find that the average turbine-inlet temperature will be 1070 F.

Entering Fig. 2, with a turbine-inlet temperature of 1070 F, we find that 176,500 Btu per 1000 lb of air are available in the turbine exhaust, giving a total of 122,000,000 Btu per hr. Since we have assumed that our flue-gas temperature will be approximately 350 F (98.8 Btu per lb gas) the stack loss will be 68,200,000 Btu per hr.

Entering Fig. 3, with a turbine-inlet temperature of 1070 F and an atmospheric temperature of 60 F, we find that we require 9.1 lb of fuel per 1000 lb of air. The total fuel required for the turbine combustion chamber is then 6280 lb per hr.

Now, if we assume that for every 1000 lb of steam generated we blow down 100 lb of boiler water, we will require an exchange of approximately 1,020,000 Btu per 1000 lb of steam in the boiler when the feedwater temperature is 220 F. This means that the total heat exchange must be 60,700,000 Btu per hr for a steam generation of 59,500 lb per hr.

Using the foregoing data for a boiler heat balance, we see that we must burn 371 lb of additional fuel in the boiler combustion chamber. Therefore in order to meet the annual factory demands of 50,000 lb per hr of steam and 4000 kwhr, we require 6651 lb of fuel per hr.

Since the industrialist is primarily interested in the efficiency with which the heat in the fuel is converted into power or steam available for the factory, the term "over-all efficiency" of an industrial power plant, as used in this paper, may be defined as the heat equivalent of the power available for the factory, plus the heat in the steam available for the factory, divided by the heat content of the fuel required. The over-all annual efficiency of our gas-turbine plant is then 59.4 per cent.

ADVANTAGE OF GAS-TURBINE-PLANT REFINEMENTS

In our basic gas-turbine industrial power plant, we have already used a waste-heat boiler instead of regenerators to improve the plant efficiency. Therefore there is no need to consider the use of regenerators in our plant. However, let us assume that we add compressor interstage cooling to our basic gas-turbine unit. Compressor interstage cooling will reduce the work required for air compression but will affect neither the total work done by the turbine nor the enthalpy of the turbine exhaust. Therefore the work available for power generation will be increased. This in turn will reduce the total weight of air required for a given design power generation. But reduction of the total weight of air required will reduce the total weight of gas entering the waste-heat boiler, thereby reducing both the heat available for steam generation and the heat loss in boiler-stack gas. The net result will usually be a slight increase in the over-all plant efficiency even though we will have to increase the fuel burned in the boiler combustion chamber.

Now assume that instead of adding compressor interstage cooling, we add turbine interstage reheating to our basic unit. In this case, while the work required for air compression is not changed, the work done by the turbine is increased, thereby increasing the work available for power generation and decreasing the total volume of air required for a given design power generation. Also, the enthalpy of the turbine exhaust gas is higher than if no reheating were used. This increased enthalpy will probably more than compensate for the lower gas flow, because the heat available for steam generation will increase and the stack loss will decrease. The net result will probably be a fairly substantial increase in the over-all plant efficiency.

If we add both compressor interstage cooling and turbine interstage reheating, we will of course have the combined advantage of the separate additions.

MULTIPLE-SHAFT TURBINES

The additions so far considered have been additions to single-shaft units whose output, for practical and design considerations, has been controlled by controlling turbine-inlet temperatures while maintaining constant the volume of air compressed. Inspection of Figs. 1 and 2 shows that the steam generated by unreheated turbine exhaust gas will decrease as the power generation decreases. On the other hand, since the gas flow remains constant, the stack loss remains constant. Therefore plant efficiency decreases as the power generation decreases. The use of multiple-shaft units allows us to control the output of the turbine by controlling both the turbine-inlet temperature and the volume of air compressed. The net result on the over-all power-plant efficiency will probably be that while the efficiency at full load will be approximately the same as the full-load efficiency for a single-shaft unit with turbine interstage heating, it will not fall off when power generation is decreased. The reason for this is that as power generation is decreased, the gas flow is also decreased, thereby reducing the heat lost in the boiler-stack gas.

Of course, any of the additions mentioned will add to the inital cost of the gas turbine. Whether or not this increase in capital investment is economically justified will depend upon a number of factors. Since these factors vary with each plant, no attempt will be made to evaluate them in this paper.

COMPARISON WITH STEAM-TURBINE PLANT

Now let us see how our basic gas-turbine plant will compare with an extracting and condensing steam-turbine plant furnishing the same annual power and steam demands to the factory.

We have defined "over-all plant efficiency" as the useful heat delivered to the factory, divided by the heat content of the fuel consumed. As a corollary of this definition, we might define the "over-all plant inefficiency" as being the heat lost out of the power plant, divided by the heat content of the fuel used. From this we see that the least inefficient plant (or the most efficient plant) is one in which there is no heat lost out of the plant. In a straight back-pressure plant, the great heat loss is, if we neglect minor losses, the heat in the stack gas. Since this loss is governed by boiler efficiency, we can consider the over-all efficiency of the plant to be the same as the boiler efficiency, which will probably be in the neighborhood of 82.5 per cent. The great heat losses occurring in an extracting-condensing steam-turbine plant are, if we neglect minor losses, the stack loss and the loss of heat given up to the condenser circulating water. When power is generated condensing, the over-all plant efficiency drops as the percentage of the total power generated on the condenser increases. A plant generating 100 per cent of its power on the condenser will have an over-all efficiency of about 25 per cent in the average industrial plant. This relationship between the percentage of power generated condensing and the over-all plant efficiency is shown in Fig. 4.

In an industrial extracting and condensing steam power plant, the percentage of the total steam generated which is extracted for use in running auxiliaries and heating feedwater will vary, but let us assume that it is 22.5 per cent. Then the total steam generated will equal the sum of the steam extracted for the factory plus the steam extracted for use in the power plant (22.5 per cent of the steam generated) plus the steam to the condenser. If in our particular plant we assume that there will be no steam to the condenser, the total steam generated will be approximately 64,500 lb per hr.

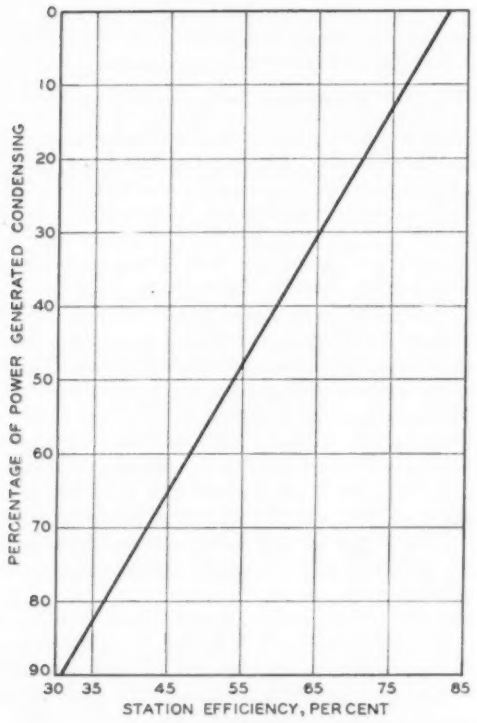

FIG. 4

If the plant were a 400-psi plant and the turbine steam rate extracting were 43 lb per kwhr, the total power generated extracting would be 64,500 / 43 = 1500 kwhr. This is insufficient to meet factory demands and some power must be generated on the condenser. The percentage of power generated condensing will be 2500 / 4000 = 62.5 per cent of the total power generated. Referring to Fig. 4, the over-all plant efficiency will be approximately 46.5 per cent.

If the plant were a 600-psi plant and the turbine steam rate extracting were 35 lb per kwhr, the total power generated extracting will be 64,500 / 35 = 1840 kwhr and the percentage of power generated condensing will be 2160 / 4000 = 54 per cent. Referring to Fig. 4, the over-all plant efficiency will be approximately 51.5 per cent.

Summarizing the over-all plant efficiency of the various plants, these efficiencies are as follows:

(*a*) Gas-turbine plant with 150-psi waste-heat boiler, 59.4 per cent.

(*b*) 600-psi extracting and condensing steam plant, 51.5 per cent.

(*c*) 400-psi extracting and condensing steam plant, 46.5 per cent.

It is the author's belief that even though the gas-turbine plant uses fuel oil while the steam plant is using coal as a fuel, the lower capital investment required for a gas-turbine power plant, and its higher over-all plant efficiency, will result in a greater annual return on the capital investment than will the more expensive less efficient steam plants. If the time ever comes when it is feasible to use pulverized coal as a fuel, the use of gas turbines and waste-heat boilers in industrial power plants will be even more advantageous.

POSSIBLE APPLICATIONS OF GAS TURBINE AND WASTE-HEAT BOILER

Now let us indicate a few situations in which the gas turbine and waste-heat boiler might be used. From the discussion which has been presented, it can be seen that such a plant might be considered for a new industrial establishment. It might be considered for the extension of an existing power plant which can no longer meet the factory demands for power. It might be used to convert an existing steam plant to a steam and power plant using existing boilers as waste-heat boilers; or it might be used to replace condensing turbines in existing plants in which both extracting-condensing turbines and straight-condensing turbines are in use. These situations are quite broad in scope and are capable of being expanded to cover many special situations.

CONCLUSION

As was stated in the introduction, the purpose of this paper has not been to present an exhaustive study of the use of a modern gas turbine in the industrial power plant. The author realizes that many of the assumptions made are matters of opinion. At the same time, it is not believed that the assumptions made are so wide of the mark as to prejudice the premise prompting the discussion. He also realizes that the discussion has been quite elementary. It has purposely been kept at an elementary level as it is hoped that, if quick and simple means are at hand to make a preliminary estimate of the performance of a gas-turbine and waste-heat-boiler installation, engineers will be more tempted to make such an estimate before deciding definitely on some other type of installation. If such an estimate shows that there might be an advantage in the use of gas-turbine and waste-heat-boiler plant, a more elaborate and detailed study could be made after consultation with gas-turbine manufacturers.

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20,000-Kw Gas-Turbine Plant

ONE of the largest Swiss power companies, the N.O.K., has decided to build a 20,000-kw gas-turbine power plant in the northeastern part of the country. This plant will supplement the winter energy obtained from existing hydroelectric stations. Its power unit, which will be built by Sulzer Bros., Winterthur, Switzerland, will operate on the special high-pressure cycle developed by that firm. It will drive a 25,000-kva generator. The capacity of the station's oil tanks will correspond to a production of 60 million kwhr. It is expected that the plant will be put in service during the winter, 1949-1950.

This will not be the first large gas-turbine unit built by Sulzer. They expect to have in operation, long before this 20,000-kw stationary unit, a marine gas-turbine plant of around 7000 hp which will be installed on a ship after completion of shop tests.

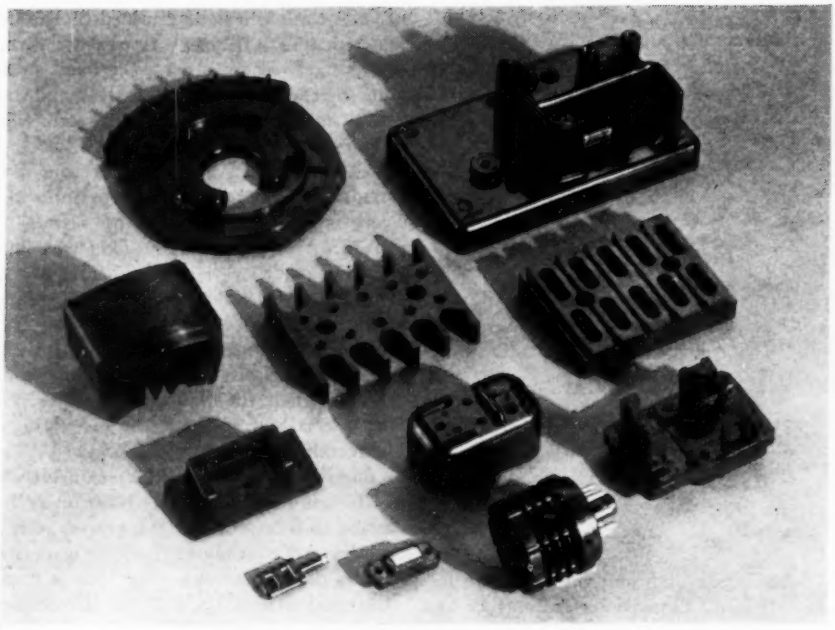

FIG. 1 TYPICAL PARTS MOLDED TO PRECISION TOLERANCES

MECHANICAL PRECISION *in* MOLDED PLASTICS PARTS

By S. K. MOXNESS[1]

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PHENOLIC molded parts for all types of instruments are now in greater demand than ever before. Whether it is the simplest thermostat or the most complicated control device, many of the essential parts are made from molded phenolformaldehyde materials, Fig. 1. One obstacle to still greater use of phenolics has been that it is difficult to hold dimensional tolerances found practical in metals.

Certain standards have been established for the plastics industry as practical tolerances for phenolics. It is felt that these tolerances are suitable for average molding. However, there is a small percentage of parts, namely, in the instrument and control field, which fall into a somewhat different category from the average molding process. If certain tolerances on the plastic parts could be held, the design engineer might be able to save a considerable amount in the cost of the instrument. When necessary, it has been found that conventional tolerances of ±0.003 in. per in. can be cut to ±0.0015 in. per in., and these dimensions maintained under normal conditions.

Much research has been done on precision molding during the last few years. Many large concerns doing their own molding are demanding closer tolerances but the advantages gained by this increased precision must be carefully balanced against the increased cost of molded parts.

REQUIREMENTS FOR PRECISION MOLDING

Many elements enter into so-called precision molding. Strangely enough, the most important thing is that the designer permit as much tolerance as feasible on all dimensions. He should use fractional dimensions wherever possible and maintain close tolerances only where they are absolutely required. Holding dimensions to ±0.0015 in. per in. on a few dimensions is not too much trouble.

It is also important that the mold be made as accurately as possible. To make a 12 to 16-cavity production mold according to blueprint on all dimensions is not easily done even with tolerances of ±0.005 in. Cut a few of these mold tolerances to ±0.002 and the mold cost may easily be doubled. Considering that some molds may have 30 to 40 dimensions in each cavity, it may be realized that the likelihood of obtaining correct dimensions on all cavities is very slim.

Experience of the author's company has shown that few multiple-cavity molds can be made to pass inspection on every dimension. For this reason a smaller number of cavities is used where close tolerances on the parts are required. To make 2 or 4 cavities correctly is quite possible. The molding cost will go up but this usually can be justified by the advantage of closer dimensions.

[1] Chief Process Engineer.

Contributed by the Rubber and Plastics Division and presented at the Annual Meeting, New York, N. Y., December 2–6, 1946, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

FIG. 2 THE M10 PERISCOPE HEAD

The uniformity of bulk factor and moisture content has proved very important. If mold dimensions are correct and material uniform, it has been found that the density and dimensions of castings can be made to vary considerably, both in compression- and transfer-type molds. Various other elements also enter into this type of molding, such as preheating of powder, mold temperature, and time.

Postconditioning of molded parts is being utilized when some extreme dimension must be held. This amounts to afterbaking parts to accelerate the aftershrinkage.

PERISCOPE HEADS PRECISION-MOLDED

To illustrate precision molding, consider the procedure that was used to control dimensions on the M4 and M10 periscope heads. These castings had been in production several years, so it was possible to observe many changes in technique. The M4 head was 6.437 in. $\left\{\begin{matrix}+0.000 \text{ in.} \\ -0.010 \text{ in.}\end{matrix}\right.$ long. It had fourteen holes for 4 × 36 self-tapping screws cast in it. The holes had a tolerance of ±0.003 in. on 1.437-in. centers, Fig. 2. The tolerance was required as the plastic part had to match the countersunk holes on a stamped window frame. This tolerance was not unusual, but to make 48 compression cavities with an over-all tolerance of $\left\{\begin{matrix}+0.000 \text{ in.} \\ -0.010 \text{ in.}\end{matrix}\right.$ on a 6.437-in. dimension meant accurate workmanship. The only way to hold the mold dimensions to the limits required was to use the laminated type of mold construction, Fig. 3. This made it possible to grind almost everything after hardening. The most difficult problem occurred when the hole-to-hole distance changed in hardening, using up almost the entire part tolerance in the mold. It was necessary to leave holes undersize and jig-bore them with carbide-tipped tools after hardening. Fig. 4 shows a mold in the press.

These molds were actually made to lamination-die tolerances. The clearance between force and cavity, the flash escapes, and the landings were held to ±0.001 in. and then polished to a mirror finish. This work may seem unnecessary but it is now understood that this made it possible to do the job. The theory is that the back pressure of the mold is determined by the fit around the force and flash escapes. If some cavities did permit material to escape more freely than others, the back pressure varied, thus also varying the density of the casting and the shrinkage.

An important but unknown factor was found in the plastic materials and their uniformity. Each barrel of powder was mixed and rolled before preforming, and each operation was maintained as uniformly as possible. In spite of this, the rejects were high. Everything seemed to point toward nonuniformity of materials. This was finally proved when one supplier made available a general-purpose material which ran very uniform. This material apparently was similar to the others, but it performed much better. The reason for this successful performance is still not fully known. Nevertheless, this proved that there may be something the material supplier can do to help the industry, even if such help would cause prices of material to run higher. When close dimensions are required, material cost plays a minor part. This particular material reduced the number of rejects considerably.

Running a steady cycle both on preheating and curing was found to be essential. All presses were operated by automatic timers. A continuous check by inspectors warned the operator if his parts were changing. By a combination of control of heat and weight, the 6.437-in. dimensions could be varied up to 0.015 in. in length.

If preforms ran heavy, the part would run long and a small piece of the preform was broken off until new preforms were made. If preforms ran light, a tiny preform would have to be added. Almost every time a new batch of material was started some element in the molding cycle had to be adjusted. It was found at times that some cavities required slightly different weight from the others. This could be caused very readily by a difference in the temperature in two cavities side by side; for example, if the steam plates became water-logged in places. It could also be that the flash escapes were slightly larger than those in the other cavities. The clearance between force and cavities, and the size and position of flash escapes

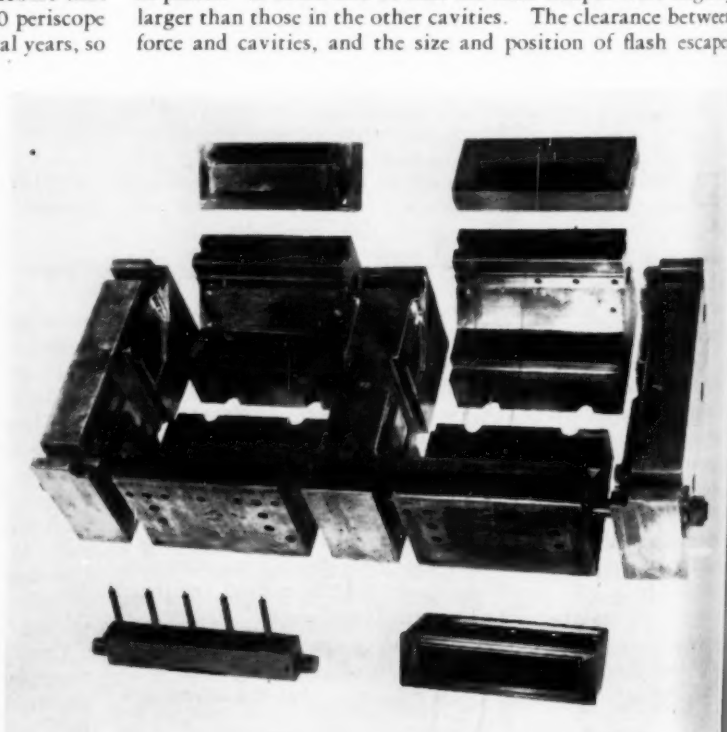

FIG. 3 EXPLODED VIEW OF 4-CAVITY MOLD FOR M-4 PERISCOPE HEAD, SHOWING LAMINATED CONSTRUCTION

proved important. Density of parts varied with these factors.

A variation in temperature or preheating time would usually show up on the 6.437-in. dimension instantly. Of the various types of preheating used, the electric circulating oven seemed the most reliable. The average preheat time to obtain correct shrinkage was 10 min at 180 F. Raising the temperature in the oven would reduce the shrinkage; lowering it would increase shrinkage.

High-frequency preheating was also used, but if heated to a soft condition it was found that the dimension varied too much. In preheating to a high temperature in the high-frequency unit the shrinkage was increased. This appears quite natural as the quick preheat does not dry out preforms as much as the dry circulating oven does. By slowly heating preforms to 180 F in the high-frequency units, the dimensions corresponded to those heated in the dry oven. The shrinkage in these parts was uniform for the entire length. Shrinkage between the various holes was also found to be uniform. If a flash groove appeared to permit more material to escape than another, it always showed up by a slight increase in shrinkage between the holes at that place.

THE M10 PERISCOPE HEAD

The M10 periscope head was approximately 7 in. long and was also molded to a tolerance of $\left\{\begin{matrix}+0.000\text{ in.}\\-0.010\text{ in.}\end{matrix}\right\}$. This part had twenty-four holes to be cored for 4 × 36 self-tapping screws. The shape of the part was such that it was necessary to use transfer molding for maintenance reasons.

By altering the speed and pressure on the transfer rams, some rather interesting dimensional changes occurred. While using conventional electric preheating ovens the over-all length could be varied by only 0.006 in. to 0.007 in. A shrinkage of 0.007 in. to 0.008 in. per in. had been expected but it was found to be only 0.005 to 0.006 in. Using high-frequency preheat, it was possible to vary this 7-in. dimension up to 0.030 in. Various speeds and pressures were tried to find the most stable conditions for casting. The idea of filling a cavity in a matter of 2 or 3 sec proved undesirable in this case as the shrinkage was least uniform at this speed. It was found that when filling cavities in 15 to 17 sec the foregoing dimensions were the best. At times a 45-sec transfer time was needed. Often it was necessary to preheat preforms in an electric oven at approximately 150 F before placing them in the electronic preheater. Naturally, as the moisture varies in the preform, the loss factor changes and this variable becomes evident when electronic preheating is used. Considerable difficulty was met in holding this $\left\{\begin{matrix}+0.000\text{-in.}\\-0.010\text{-in.}\end{matrix}\right\}$ tolerance but it is felt that, if the mold had been made to a lower shrinkage dimension so that dry preheat could have been used, this part would have been much easier to mold to size.

GENERAL MOLDING CONSIDERATIONS

When molding to close tolerances in transfer molding, small gates are desirable only on small castings. Gates 0.020 in. thick are considered small gates. On large castings the gate size must be large enough to be able to distribute the back pressure evenly. If part of the casting starts to cure before the cavity is full, the shrinkage will vary in different sections of the part. No shorter cure time was obtained with the small gates, probably because the runners were fairly long.

To stabilize dimensions on any molded part, afterbaking is used to a great extent. Parts are placed in ovens at temperatures varying with the type of material used. This process improves electrical qualities besides accelerating warpage and aftershrinkage. To demonstrate the stability which may be attained, several of the periscope heads were afterbaked and given careful checks at intervals over a period of nearly 2 years. Some were stored at room conditions, others placed in a hot boiler room, and some exposed to the elements. The greatest dimensional change noted during this test amounted to 0.003 in. on a part 7 in. long. These parts were molded from a general-purpose material.

It must be emphasized that such precision can be expected only when the factors of part design, mold design, and construction, uniformity of materials, preheating, correct cycling of operation, and postconditioning are properly considered. With the automatic molding press coming into its own so that many of the factors are uniformly maintained, it appears that a large part of the responsibility for precision molding will rest on the material manufacturers.

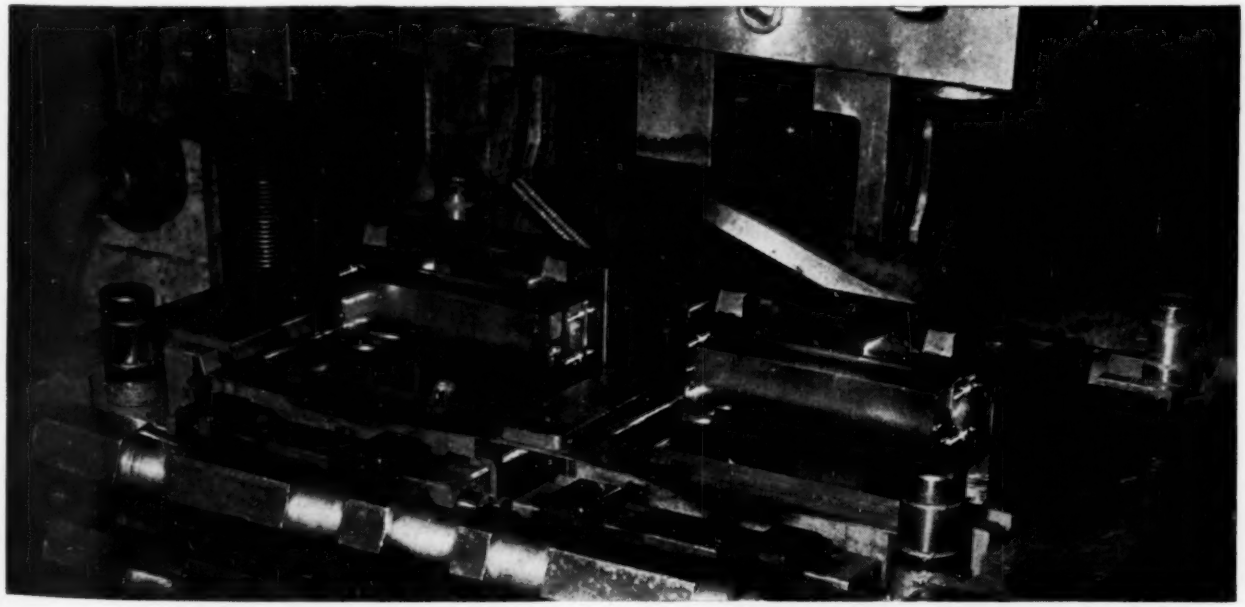

FIG. 4 VIEW OF THE 4-CAVITY M4 PERISCOPE-HEAD COMPRESSION MOLD IN THE PRESS

STRESS INVESTIGATIONS *of* FLAT WELDED-IN HEADS

By H. M. SPRING, JR.[1]

MUTUAL BOILER INSURANCE COMPANY OF BOSTON. MEMBER A.S.M.E.

THE limitation of allowable working pressures for certain pressure vessels during the last several years has led to rather strenuous objections by some of the owners. In most cases the vessels involved were cylindrical tanks having welded-in flat heads for end closures. The maximum allowable pressures for such vessels, limited by head design, were based on the formula appearing in the A.S.M.E. Code for Unfired Pressure Vessels.[2] The formula transposed in terms of maximum allowable pressure is

$$P = \frac{St^2}{d^2c}$$

where P = maximum allowable pressure, psi
S = maximum allowable unit working stress as given in Code Table U-2
t = thickness of head, in.
d = inside diameter of shell with heads designed as illustrated in Fig. 1
c = constant of 0.5 for the design of Fig. 1

One outstanding example of the objection was with a small pressure vessel made up of a length of 8-in. pipe with flat welded-in heads, 1/2-in. thickness. According to the code formula, the maximum allowable pressure would be 86 psi. An operating pressure of 200 psi was desired, and the owner subjected the tank to a hydrostatic test of 1500 psi, with no visible indications of distress. When the recommendation to follow the A.S.M.E. Code was again made, the owner repeated the hydrostatic test, this time at 2000 psi with no visible permanent set. Unfortunately, no precision measurements were taken when this test procedure was carried out. Based on the tests and due to the fact that the tank was not in a state that had adopted the A.S.M.E. Code, a maximum allowable pressure of 200 psi was approved.

Following several similar incidents with pressure vessels of larger diameters, it was decided to investigate further the design of flat welded-in heads. Firsthand information was desired in order to evaluate the safety of this design for allowable pressures in excess of code limits for vessels outside the scope of any state regulations. It is emphasized, however, that the A.S.M.E. Code should be followed strictly where state or municipal regulations are in force.

TEST PROCEDURE

To obtain test data that would be of most value toward the purpose described, it was decided to fabricate a pressure vessel with flat heads designed and constructed in strict accordance with the A.S.M.E. Code for Unfired Pressure Vessels. The heads were designed to comply with Fig. U-4(f) of the Code. The welded joint was not stress-relieved since it would not be a requirement for a "U-69" vessel for the design shown.

The material used for the heads was open-hearth flange-quality steel which permitted a maximum operating stress of 11,000 psi at temperatures up to 650 F, according to A.S.M.E. Table U-2. Accordingly, the test procedure was designed to reveal by hydrostatic test and use of SR-4 strain gages just what internal pressure would develop a stress of 11,000 psi in the head.

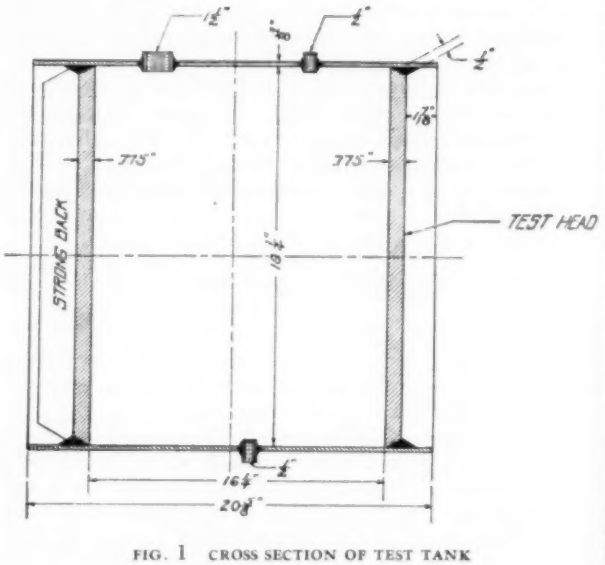

FIG. 1 CROSS SECTION OF TEST TANK

With this information, it was planned to apply the test pressure in pulsations to determine whether a fatigue failure would occur during application of 10,000,000 cycles of pressure impulses varying from as near zero as possible to the pressure developing maximum allowable stress.

If no fatigue failure occurred, it was planned to increase the pressure by further hydrostatic test to the point of destruction, taking suitable measurements to reveal the proportional limit of the flat head.

The strain-gage tests were conducted by the author's company on August 30, 1946. The fatigue tests and test to destruction were made at the Hodge Boiler Works, East Boston, Mass.

Test Specimen. The test vessel, shown in cross section in Fig. 1, and identified by MCO No. 46555B, was fabricated by the Hodge Boiler Works.

Since but one head was being investigated, it will be noted that the opposite head was reinforced with a strong back so there would be no possibility of failure in the second head. Table 1 shows the mill-test-report data for the physical and chemical properties of the test head. The material conforms to code requirements for SA-70 steel.

According to A.S.M.E. Code calculations, the test head would be permitted a maximum working pressure of

$$\frac{11{,}000 \times 0.775^2}{19.25^2 \times 0.5} = 35.6 \text{ psi}$$

[1] Assistant Chief Inspector, Boiler and Pressure Vessel Division.
[2] Paragraph U-39(*a*), 1946 edition.

TABLE 1 MILL-TEST-REPORT DATA FOR FLAT HEAD IN TEST TANK NO. MCO 46555-B

Material—SA-70 Steel—Flange Quality
Lukens Steel Company
Mill Order No. 11491

Melt no.	23366	Slab No. 2
Carbon	0.20	
Manganese	0.45	
Phosphorus	0.014	
Sulphur	0.034	
Test piece:		
Thickness No. 1	0.768 in.	
No. 2	0.752 in.	
Section area	1.121	
Section area	1.089	
Yield point	37,100 psi	
Tensile strength:		
No. 1	60,400 psi	
No. 2	58,900 psi	
Elongation, per cent	32	

The shell would be allowed

$$\frac{11{,}000 \times 0.375 \times 1.00}{9.625 + 0.6 \times 0.375} = 417 \text{ psi}$$

calculated by the formula U-20.

Static Test. To reveal radial and tangential stresses under hydrostatic test pressure, strain gages were attached to the head and located as shown in Figs. 2 and 3. The first application of pressure after venting air was at 35 psi. The pressure was raised to 50 psi, then in increments of 5 psi to 110 psi maximum, taking strain-gage readings at each step.

The curves in Fig. 4 were plotted to illustrate stressing due to applied pressures. It will be noted that data from the static tests indicate that a pressure of 93 psi is required for development of 11,000 psi maximum stress in the flat head.

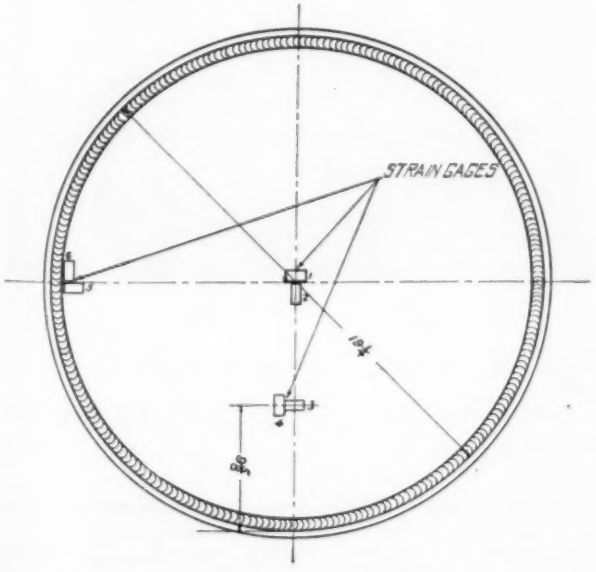

FIG. 2 POSITION OF STRAIN GAGES ON HEAD OF TEST TANK

Fatigue-Endurance Test. The setup for the fatigue-endurance test is illustrated in Fig. 5. By adjustment of the amount of air in an air-cushion chamber (not shown) on the pump discharge and by adjustment of the bleed-off valve, it was found that a pressure cycle of 20–93–20–93 psi was developed by each complete stroke cycle. With the double-acting pump operating at 60 strokes per min, pressure impulses at the rate of 120 per min were obtained.

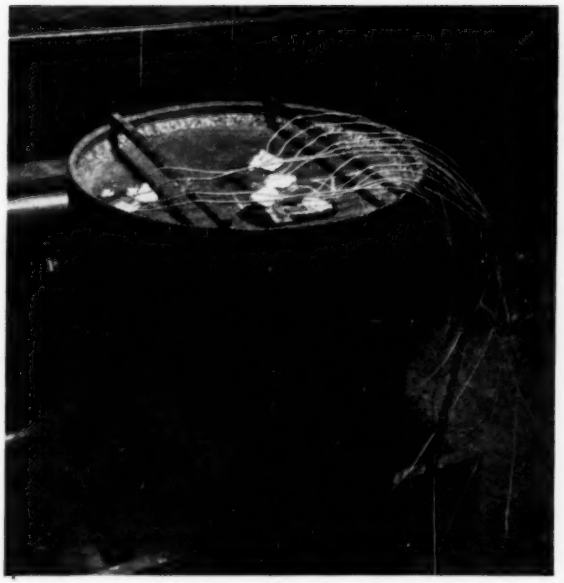

FIG. 3 VIEW OF TANK WITH STRAIN GAGES IN PLACE ON TEST HEAD

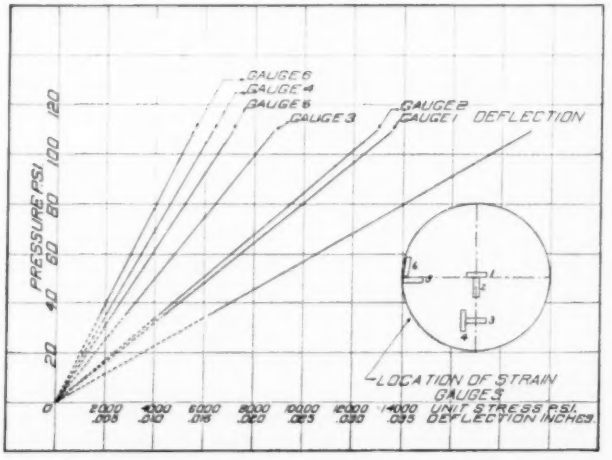

FIG. 4 CURVES SHOWING STRESSING DUE TO APPLIED PRESSURE

Starting on September 24, 1946, the fatigue-endurance test proceeded until on November 21, a fracture in the shell plate occurred. The pressure cycles numbered 7,946,400 at the time of failure.

The failure was in the nature of a circumferential crack that extended through the shell plate about midway in the thickness of the test head. Leakage occurred over a length of 2.63 in. along the crack. The total circumferential length of the crack visible on the outer surfaces was 5 in.

The fatigue test was considered completed and the crack was gouged out for full thickness for repairing by electric welding prior to a test to destruction. In cutting out the shell plate to prepare a joint for welding, it was discovered that the crack extended, subsurface, for approximately 12 in.

No defects in the test head or its weldment were discovered by visual examination.

DESTRUCTION TEST

The test tank with a dial indicator suitably mounted to measure deflection at the center of the head, was connected

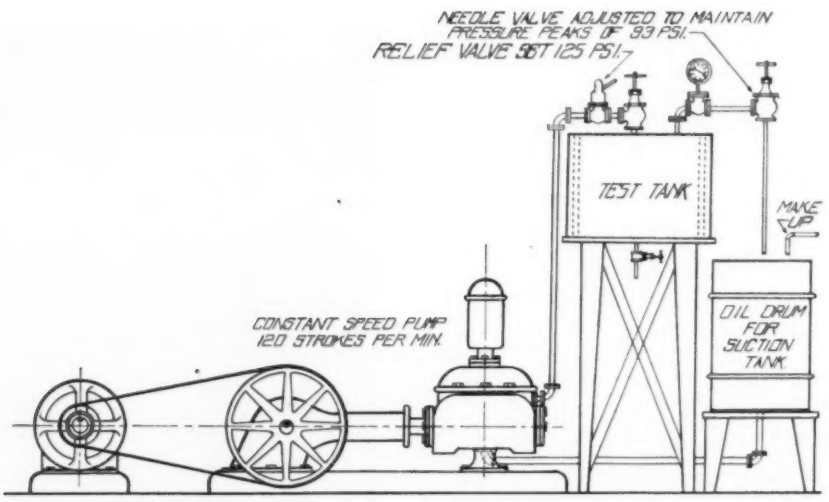
NEEDLE VALVE ADJUSTED TO MAINTAIN PRESSURE PEAKS OF 93 PSI.
RELIEF VALVE SET 125 PSI.
TEST TANK
MAKE UP
CONSTANT SPEED PUMP 120 STROKES PER MIN.
OIL DRUM FOR SUCTION TANK

FIG. 5 SETUP FOR FATIGUE-ENDURANCE TESTS

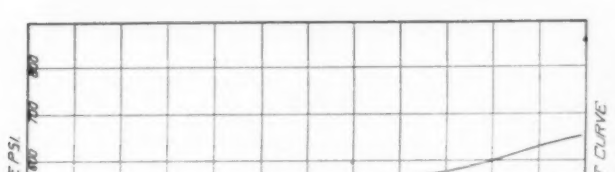

FIG. 6 PRESSURE-DEFLECTION DATA

FIG. 7 FAILURE OF SHELL

to a test pump. Starting with an initial pressure of 50 psi and returning to zero after each application of pressure, the test pressure was increased in increments of 10 psi, until it became obvious that the proportional limit had been exceeded. The curve, Fig. 6, illustrates the pressure-deflection data. Applications of pressure continued without rupture to 800 psi, the limit of the test pump. Deflection readings became inaccurate because of excessive distortion at 800 psi and they were discontinued.

The test tank was then piped to a hydraulic accumulator and the high pressure was admitted to the test tank through a control valve. The hydrostatic pressure was gradually increased. At 1100 psi a sharp snap was heard but there was no visible indication of failure. Complete failure occurred at a pressure of 1340 psi in the nature of a circumferential fracture of the shell plate, Fig. 7. The failure was in line with the fatigue crack described.

Close examination revealed that an initial fracture occurred starting from the fillet weld and progressing outward for about 50 per cent of the shell thickness. This fracture had a woody fibrous appearance. The remainder of the shell fracture was of fine granular character.

A surface defect about 4 in. in length on the inside of the head was found 1 in. from the center. This defect was spotted with a drill and found to have no appreciable or significant depth.

Radial strain lines were apparent on the inner surfaces of the test head.

CONCLUSIONS

The initial failure by the fibrous-appearing fracture is believed to be due to the influence of heat runoff from the weldment which was not stress-relieved. The secondary or final failure suggests by appearance a normal fracture of overloaded low-carbon steel unaffected by heat of welding.

The fact that the failure occurred in the shell plate rather than in the flat unreinforced head appears significant. While failure in the shell plate prevented carrying the fatigue tests to 10,000,000 cycles as had been planned, the tests do appear to indicate that the head would have been safe for a useful life at pressures considerably in excess of 36 psi. In fact, with the code formula for flat heads, the 93 psi which developed a stress of 11,000 psi would appear to suggest a constant of 0.192.

ENGINEERS ARE *Also* CITIZENS

The Challenge of Power

By R. M. GATES

PRESIDENT, AIR PREHEATER CORPORATION, NEW YORK, N. Y. PAST-PRESIDENT A.S.M.E.

IT IS highly appropriate that a power conference should consider the problem of the public responsibilities of engineers. Scientists and engineers have progressively harnessed Nature to provide mankind with tremendous power. Though terrifying in its destructive uses, this power in its constructive uses, actually and potentially, is an immeasurable contribution to the advancement of human welfare. Even the pressure of war has speeded technical progress applicable to the arts of peace.

But the creators and developers of our modern technology have not given due attention to the increased responsibilities which the possession of such power imposes on citizenship in a high-powered society. As has been wisely said, we have put high voltage into old wiring. Human relations have not been adjusted to the new technology. Communities, states, and nations cannot "carry the load." The fuses have been blowing out all along the line.

The achievements of scientists and engineers, and of businessmen using their services, have made it clearly possible to lift a great portion of the drudgery of the world off the shoulders and muscles of men. They are placing it upon the oil wells, the waterfalls, and the dynamos, upon countless machines so powered, and upon technical processes requiring a minimum of toil. They have given modern men a vision of plenty that may be peacefully shared, instead of scarcity that breeds conflict. But how much less of intelligent effort has been expended, how much less of achievement has been recorded, in the organization and adaptation of human nature and human institutions, to use these resources for the benefit of mankind and to realize this prospect of plenty and peace! Has not human ingenuity faltered at this threshold of opportunity?

SPECIALIZATION TENDS TO NARROW PERSPECTIVES

We live in an age of specialists. Specialization has been a major factor of our material and social progress. The tools men used were once the work of their own hands. A modern machine, or even the simplest tool, is now the product of many workers. No one of them contributes more than a small part of the labor required, and usually none of the power and none of the old-time craftsmanship. The jack-of-all-trades has nearly disappeared from industrialized America. The scientist, generally, cannot be the master of more than a small area within one science. The versatility of a Leonardo, a Bacon, a Galileo, or a Newton does not fit into the current scientific scene. Even Edison limited himself to a few fields of exploration. Engineering, like other professions, has been divided into many specialties. Even though the dividing lines are often blurred and crossed, the tendency to specialization increases with our growing factual knowledge. All this specialization has its advantages but also its dangers. It makes for occupational isolationism.

No occupation can successfully isolate itself from concerns common to all. We are all sharers in responsibility for government. In a government of the people by and for themselves, in our form of democracy, the active participation of every economic group, including every professional group, is needed. The rules of society within which all the people carry on their several occupations are matters of politics; so are the many services which the people wish their governments to render. The sphere of government in which the politician is a specialist has expanded with the growing complexity and interdependence of our economic and social life. This is true of government at every level—local, state, national. We all share in paying a constantly heavier toll for inefficient and short-sighted management of these expanding public interests. Nor is it merely a toll in taxes; it is also a toll in national strength and security.

The new power, the new materials, the new processes, which engineers have applied to industry have wrought a revolution in our ways of life and in our human relations; and the revolution has obviously only begun, for no moratorium in science has been declared. This power age sees new aggregations of human power also. The increasing power of government is largely an outgrowth of the increasing power of aggregations of capital and labor; of nation-wide and even world-wide organizations of industry, trades, agriculture, and other occupational groups. The people as members of their respective groups make new demands on government for protection, for aid, for privileges, or to be let alone, while as citizens they insist that government keep the upper hand over all groups. Internal conflict at times undermines our national unity, strength, and prosperity. Thus politics has become increasingly everybody's business.

So, too, the new mechanical power which scientists and engineers have unleashed has brought the nations of the world closer together into a neighborhood. We must call it a neighborhood since the nations are no longer far separated by time or distance; also since they have become interdependent, since none may suffer or prosper without affecting others, and since they are exposed together to contagions—economic, political, and what not. Their relations in some respects, it is true, may not be in all cases what we call neighborly—but we do not always have neighborly feeling among neighbors in the same community.

Our relations with other nations are matters of politics as well as economics. These two aspects cannot be divorced. Have all groups among us raised their sights to this world situation, not only as members of one national household but also as dwellers in a larger neighborhood?

Are we engineers as a group isolationists in respect to the responsibilities of citizenship, isolating ourselves from the politics of our local communities, our states, our nations, our world? Have we taken up the challenge of new mechanical power and new organizational power to human relations?

FORGOTTEN OR FORGETTING CITIZENS?

In public service of course countless engineers are professionally and gainfully employed. They plan and build the highways and subways, the bridges and dams, the water-

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supply and sewage-disposal systems, the canals and port facilities, whatever undertakings of town, city, county, state, and federal governments require engineering techniques. The Panama Canal, the Tennessee Valley, and Columbia River projects, the Chicago Sanitary District, and the New York and Los Angeles water systems are outstanding examples of their professional public service. Every state, every city, almost every town employs engineers for planning, construction, and maintenance of essential utilities. City managers are usually engineers.

In war the service of engineers has become indispensable, both in the fields of military operations and in the supporting areas at home. In the recent war, thousands were enlisted in the uniformed military services; others as civilians in various war activities both at home and abroad. The presidents of several of the great engineering societies formed a National Engineers Committee which served the State Department. Its report on disarmament of Germany was so well received that it was asked to prepare a similar report on Japan. It also assisted in the selection of civilian experts to aid the occupation forces in Germany. The service of the Engineers Joint Council, in an advisory capacity, was continuously available to the Government.

The amazingly rapid improvements in aircraft and seacraft and their operating and fighting equipment, the vitally important provision of radar and other finding devices, the crowning development of the atomic bomb—these were largely the work of engineers. Much of the story of these and other contributions of engineers to victory is well known; far more, no doubt, remains to be told. To a greater extent than any other war, this was a war of engineers.

It is not engineers employed in public service as engineers, however, but engineers participating in public life as citizens, who should be the object of our concern.

If we look over the list of members of Congress, of state governors, of members of state legislatures, we find few engineers. I suspect this is true of mayors also. A year or two ago, Morris Cooke pointed out that among more than 40 organizations selected to advise and aid our delegates to the United Nations Conference at San Francisco "scientific and engineering groups were totally absent;" yet the groups chosen comprised religious, educational, legal, agricultural, racial, business, and social organizations, as, for example, Rotary, Kiwanis, and Lions Clubs. And among 400 individual consultants and advisers officially chosen from many occupations, there was only one engineer, also only one scientist. Our profession is also meagerly represented on the organizations later set up by the United Nations. Moreover, among hundreds of directors of organizations of local and national citizens' groups seeking to promote the cause of peace, we find almost no engineers. Yet peace, with the things that make for peace, is the world's most important problem, and should be America's most absorbing concern.

Some say that engineers do not like politics; others, that we are too busy in the practice of our profession. But lawyers, educators, bankers, industrialists, labor leaders, even the clergy, have their occupational interests, and yet do not regard them as watertight compartments in the "Ship of State." Inactivity in regard to civic responsibility means consent to policies and practices that we may disapprove or could help to improve; policies and practices which affect our professions or businesses as well as the whole life of our nation. If we engineers, as a profession, regard ourselves as unduly overlooked in political affairs of the highest national concern, perhaps it is because we ourselves have been overlooking some responsibilities. Perhaps our profession, in this regard, is not so much forgotten as forgetting.

PREDOMINANCE OF LAWYERS IN PUBLIC LIFE

Let us note, for purpose of comparison, the participation of the legal profession in our political life.

Here the lawyer plays by far the most prominent part. Of the 32 presidents of the United States, 23 have been lawyers—though most of them practiced politics more than law. In Congress, in state and local governments, lawyers are predominant. In the Senate of the last Congress, for example, there were 70 lawyers and two engineers; in the House of Representatives, 299 lawyers, and one or two engineers. In the present Congress, I am told, the total is four engineers.

Tradition of course is an important factor in this situation. Engineering was not generally recognized as a profession when our nation was born—certainly not in the sense that the law was recognized. Most of the educated men of the community were likely to be lawyers, clergymen, or teachers. The clergy could preach and the teachers could teach government, but the lawyers practiced it.

The profession of law by its nature was closely tied up with government. Law courts are an arm of government. For making, interpreting, applying, enforcing, and evading laws, people naturally turned to the profession in which special training and experience are found for any of those purposes.

Furthermore, lawyers are supposed to develop special skill in presenting either side of an issue persuasively. They can so analyze an issue from all sides that they can clarify or obscure it, highlight the strength or weakness of either side, or make the worse appear the better reason. This skill is useful to them in gaining or retaining public office; useful also to the political parties to which they attach themselves; and often useful to the public. The nation and its communities have a continuing need of able lawyers who will use in political life their talents and training and experience, not mainly for self-advancement or party advantages, but for public service.

THE NEED OF THE ENGINEERING APPROACH IN PUBLIC LIFE

The United States is now an industrial nation whose main economic, social, and political problems have arisen because of the achievements of science and engineering. As the creative agents of technical progress, engineers have accumulated intimate knowledge of the materials and forces that can be used to serve human needs. They have had to maintain a realism which keeps their feet on solid ground, while at the same time exerting alert imagination to discover unattained possibilities. Knowledge, realism, and some imagination make up the equipment required for engineering achievement. Can such disciplined wisdom be applied to the nontechnical problems of human relations that confront us—to the consequences of engineering achievements as witnessed in our economic, social, and political life?

These problems are different from those with which engineers normally have had to wrestle. In the study and application of inanimate materials and forces, one's self may be kept pretty much on the outside of the circle encompassing any given problem. The perspective is one from which personal likes and dislikes, and personal prejudices, are largely excluded. But it is well-nigh impossible so to detach one's self when handling human relations, or problems in which human nature is a significant factor. One's self in this area is inside the circle. Emotional reactions, conscious or unconscious preconceptions, even a philosophy of life, color judgments. A scientific objective viewpoint cannot be maintained. Therefore it is concluded the engineering type of mind is not trained for operation in such a field.

We may find some substance in this argument without accepting its conclusion. Lawyers in politics, with long training and experience in the study and adjustment of human rela-

tions, in the science and art of government, seem to differ widely both in the viewpoints from which they look at government policies and in the opinions they form about them. A quite different type of approach is often needed.

For instance, in New York, after the first world war, it required the factual grounding and the realistic imagination of Al Smith to effect an extensive reorganization of the state government. He was not a lawyer, nor a businessman, nor an academic political scientist. Though not an engineer by training, he used engineering tools—knowledge, realism, and imagination, in his attack on the problems of government. The outstanding services of Robert E. Doherty and Edward R. Weidlein, as heads of the Allegheny Conference on Community Development, were recounted in a recent issue of *Fortune*. Pittsburgh is on the way to being made over under their leadership. The program is "to get the facts, then do something about them, step by step, within a unified plan for the region as a whole." It set about to work through existing agencies, recommending or commissioning them to carry out specific projects. If an agency dawdled, it was prepared to take over the work and see that it "got done." I have already referred to some of the great municipal enterprises of Chicago, under the administration of its engineer-mayor.

During World War II, we had numerous examples, provided by members of our profession, of the handling of problems involving mainly human relations and therefore lying outside the conventional fields of engineering. The services of Charles E. Wilson of General Electric, William L. Batt, Howard Coonley, Ralph Flanders, and many others could be cited.

KNOWLEDGE, REALISM, AND IMAGINATION

Knowledge of the materials and processes employed in the manifold activities of industry has a real value in appraisal of the expanding problems of public service. It has value in formulation of public policies involving regulation of private enterprise and co-operation with it for the common welfare. Those who are trained, and disciplined by experience, to know the background and elements of a problem before they attempt to solve it are least likely to let prejudicial and wishful thinking lead them into snap judgments and half-formed conclusions.

Realism is a habit of mind not confined to any profession or occupation, but necessarily acquired in engineering experience. Not only what is the background of a problem but also what are the means practically available and the existing conditions for its solution—these are questions which the engineer is accustomed to ask and which he diligently seeks to answer. Engineers speak a common language, and have a common regard for fundamental truth. This realism is no less important in municipal, state, national, and international problems than in those of private industry.

Imagination of course is the wellspring of progress. Few, if any other occupations make such demands on creative imagination, or help so much to develop it, as does engineering. To conceive something new, and then to plan and realize it, is forever the engineer's task. His creative imagination should be used, not only in the planning and construction of public works, but also in sharing responsibility for antecedent and consequent policies. The training which makes him adaptable and resourceful in operational situations is useful in many types of governmental problems. I would not depreciate the service of politicians by profession who use their gift of leadership for the common welfare. But large responsibilities are too often entrusted to politicians whose creative imagination may be limited to building personal or party political fences.

It becomes increasingly clear, as the influence of government is expanded over a wider range of human relations and activities, that we must outgrow this conception of politics. Wherever scientific knowledge, disciplined realism, and creative imagination may be found there is certainly ample opportunity to use them in our local communities, our states, our nation, and our world. Why should we not encourage the public to turn to our profession not only for the technology that makes possible a high standard of living for our people, but also for guidance in the great task of adjusting human relations to this technological progress?

WHERE CITIZENSHIP BEGINS

It may seem that I am urging engineers to give up their jobs and devote themselves to politics, or at least to neglect their chosen profession for competition in another field already overcrowded with willing workers. Of course that is not at all my purpose. It is, rather, to suggest that too few engineers, as compared with members of other professions, are actively interested in public affairs as citizens of their respective communities and of the nation; that the engineering approach is too little utilized in the solution of problems of common concern outside of the conventional engineering field; and that engineers need to rethink their responsibilities as citizens in a society confused and floundering in efforts to adjust itself to new powers and new possibilities. Every engineer should find some time to give to civic responsibilities, and this without neglect of his professional duties. Engineering will benefit by the inspiration that grows out of these wider contacts.

One could find many engineers who have engaged actively in the life and service of their communities along lines having little or no relation to their professional activities. They have advanced philanthropy, worked in welfare activities, served as trustees of civic organizations or institutions, and led civic movements. They have maintained contact with the political machinery of their communities, served on political committees, and taken active parts in local political life.

But by and large is not a definite detachment from the political structure of our society—the basic structure, in a sense—the more common practice among engineers? In that detachment from the nontechnical world may be found the reason for some lack of recognition, by public authorities and by the people at large, of the variety of services which the engineering profession can render, and should be called upon to render, in the solution of community problems.

Since community organization is at the base of the whole structure of government, it is here that the engineer may well first try his wings as an active citizen. Responsibilities taken at this level lead to larger responsibilities he may be well qualified to take and may find satisfaction in taking. Thus an unfortunate gap in communication between our profession and the broad field of public service, unfortunate for the national welfare, may be gradually bridged.

The Committee on Engineering Education, the Engineers' Civic Responsibilities Committee, and other committees of the Engineering Societies have been emphasizing this responsibility of engineers. They have recognized not only that engineering education must train prospective engineers as to their civic responsibilities but also that such education is futile if not followed up by active participation. The old adage that we learn by doing is no less applicable to the engineer as citizen than to the engineer as engineer. It is never too late to begin. Indeed the responsibility increases as acquaintance, connections, and standing increase opportunity.

SOME PROBLEMS OF NATIONAL CITIZENSHIP

Among the current problems which occupy the political stage there are few if any which do not call for application of the engineering approach, as I have defined it, and for the partici-

pation of engineers in efforts to solve them. Without entering into details, I would mention some of these problems:

1 The American people are justly concerned about industrial relations—how the aggregations of power in industry can avoid internal conflicts that disrupt the life of the nation. We have already had strikes of such dimensions. Are engineers concerned? Of course they are vitally concerned. They range through industry from top executives to employees on weekly wages. Here is a job of engineering applied to human relations.

2 We seek efficiency and economy in government. What services of the Federal Government have outlived their usefulness? What services need to be expanded? What new services are required? How efficiently and economically are the various services rendered? These are not questions to be answered by snap judgments of the uninformed. Is this not a field in which the engineering approach is needed?

3 We find it difficult to strike a balance between freedom of enterprise and social control. What controls that seem necessary are practicable and expedient? Are present controls exercised efficiently? Engineers are in the midst of this problem.

4 How may our national resources be used most efficiently for the common welfare; in production and distribution equal to need, with adequate incentives to capital, management, and labor, with high productivity? What natural resources need to be carefully conserved, and how? Engineers, if anybody, should be able to find the answers.

AND OF WORLD CITIZENSHIP

We are face to face also with even graver international problems. They are related, of course, in one way or another, to the problems just mentioned. Let me call attention to a few, without more than the briefest comment:

1 Postwar relief and rehabilitation are economic, political, and social problems, as well as engineering problems. As regards the countries devastated by war or drained of resources by war, emergency needs must be met on a practical as well as emotional basis, with a minimum of waste and a maximum of direction toward self-sufficiency.

2 Economic development is needed by various backward peoples. They vary in natural resources, in capacity for types of industry, in economic needs, in organization of society. Our aid, where it can be offered, will be effective only if intelligently adapted and long-term guidance is given.

3 Allocation of world resources is pressed upon our attention. The world's unappropriated resources cannot become a free-for-all grab bag if world peace is to be won. The allocation and use of these resources must be adjusted not by diplomats, legislators, and military men alone, but with the aid of the best knowledge and foresight that can be enlisted.

4 What use shall be made of new sources of energy? Developments in nuclear energy seem to open a new chapter in man's mastery of his environment, perhaps in the history of mankind. Engineers opened the chapter; they will write on every page. Whatever social control of this source of energy is necessary or feasible, engineers must be responsible participants. Those who knew how to develop new sources of power for war should know how to apply them to the uses of peace.

THE CHALLENGE TO ACTIVE CITIZENSHIP

These are a few of the problems that call for a broader vision, a wider participation, a readjustment of functioning on the part of engineers as engineers, and engineers as citizens. Can we meet this challenge?

It has often been said of our profession that it has achieved increasing mastery of Nature. Somehow "mastery" has never seemed to me quite the right word. Man has not conquered Nature—even his own nature. He advances more by increased understanding of Nature than by increased conflict with it. Science humbly recognizes frontiers that it has not yet even reached in its ceaseless exploring, and seeks ever to learn more about Nature's materials, forces, and laws. Engineering, as applied science, aims to apply the findings of science to human needs, to use the resources of a bountiful Nature for human advancement. It works with Nature, in the main, not against it.

To meet human needs, to raise standards of living—that is the ultimate objective of engineering, whether in research, in processing, in designing, or in management. But fulfillment of that purpose requires many economic, social, political adjustments.

Leadership which guides aright the adjustments that must accompany technical progress must have a practical understanding of human nature and human relations. It should have a devotion to truth, not swerved by colorful half-truths or wishful thinking. It should keep a clear view of ultimate goals. Knowledge, realism, and imagination; the engineering approach is needed here where the work of inanimate nature leaves off and the forces of human nature take over. The engineer as citizen should wish to follow through, learn to follow through, and follow through. Active citizenship is the complement of successful engineering.

Yes, engineers can meet the challenge of twentieth-century citizenship individually and collectively. They have unleashed and are developing nuclear energy. Let us unleash and develop a civic energy that will entitle our profession to its proper place in the leadership of our communities, our nation, and our world.

(Into the test chamber goes part of the equipment for a radar unit being built for use aboard U. S. Navy warships. When the heavy steel door is closed, engineers can change the "climate" inside the chamber to the subzero temperatures encountered in arctic regions, or by saturating the interior with live steam, can send the temperature skyrocketing to the hot humid atmosphere of the tropical regions. In addition pressure controls make possible the testing of aircraft equipment under varied atmospheric conditions of altitudes up to 80,000 ft. Radar and communications equipment manufactured by the Industrial Electronics Division of the Westinghouse Electric Corporation for the armed forces and commercial companies, are given similar ruggedness tests.)

MANAGEMENT'S RESPONSIBILITY *for* CONSTRUCTIVE LEGISLATION

By R. ELMO THOMPSON

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DURING the great depression there was no profession in which more unemployment occurred or in which a larger number were in distress than in engineering. The number of enrollees in the engineering schools of our universities declined to such a low figure that many courses in specialized engineering were discontinued. Many intelligent young men abandoned this planned career in engineering and turned to law and business administration. Today it is interesting to observe there are 114,000 students enrolled in the engineering schools of this country which is many more than are studying engineering in all the other countries of the world combined. Still, the author is confident there are no managers of business or members of the profession who believe this increased popularity in engineering is any indication of overcrowding. It is believed to be a recognition of the dependable importance of the engineering profession in the economic future of our nation.

Prior to 1933, the study of economics was taught in colleges as an aid to a career in business. Since that year, some knowledge of that subject has created a vast new profession known as economists. From then until the present time our economy has been directed by lawyers, who are largely our lawmakers, and by economists; neither of whom is the creator of wealth or pay rolls. These two professionals have been jointly endeavoring to create prosperity and security by regulating business through the legal control of human relations, such as wages, prices, hours of work, recreation, and social security; but actually creating no greater productivity or any new things of value. The basis of the thousands of laws passed during this period by our lawyer lawmakers, inspired by certain economists, has not been to create more wealth, but to divide what we had among a greater number of people. Propaganda, and particularly the appeal to self-gain at the expense of somebody else, succeeded in advancing this general idea even to the point that our Supreme Court actually found it compatible with our written Constitution. The astonishingly revolutionary interpretation was applied that all such legislation came within the court's interpretation of those simple words, "general welfare." Without those two words in the Constitution, which have been there since 1881, the Court admitted that most such laws would have been unconstitutional.

In 1940 it appeared likely this nation would become engaged in a world war. In 1941 we were compelled to become the major participant in that war, to prevent the defeat of those nations which most nearly practice our way of life; and to prevent our own ultimate enslavement. In this national emergency, the lawyers and the economists who had been passing laws to divide the wealth of those who had some, with those who had less, were of little value. They could tell no one the kinds of machines, the types of explosives, the methods of transportation, the ways of communication, or the meaning of logistics necessary to fight a war, even if we had had all such things available. They knew much less about the number and size of war plants, where they should be located, and how they could be operated; and how they could be built in the shortest possible time, as well as manned by literally millions of individuals who knew nothing about such operations.

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ENGINEERS SUPERSEDE THE LAWYERS AND ECONOMISTS IN AN EMERGENCY

In that life-or-death emergency, this nation turned to the brains and special talents of its engineers. The magnificence of that profession's performance is evidenced by the fact that this nation was making one eighth of the war machines of its later-to-become allies in 1940; but by the end of 1944, in the short span of four years, it was making more fighting equipment than all its allies and all its enemies combined. At the same time it was producing sufficient necessities of life to maintain its home population of 130,000,000 people on a standard of living far superior to that of any other nation in the world. This fantastic almost unbelievable accomplishment which has preserved this nation, is credited to the engineering profession of America to a higher degree than to any other profession.

Now that the war is over, we are involved in another life-and-death struggle to prevent a depression of disastrous proportions which has always followed every war we have engaged in. To prevent this depression, the nation desires continuous employment of the maximum number of employables at the highest possible wages; and to produce an uninterrupted flow of products which will be sold at a profit, but at prices less than they are now being sold. In addition, the nation knows that we produce more of almost everything than we can use; in the past this excess has totaled 10 per cent of our total production. This percentage may soon become greater because of our vast increase in productive capacity. The surplus production must be sold to foreign purchasers or there will be a decline in the number employed, as well as in the value of all commodities, because the price of a surplus will eventually affect the price of the whole. To sell our surplus products in foreign countries in competition with cheap labor, long hours of work, and depreciated currencies, and to buyers with little to pay, and just break even on the program, will tax to the maximum the engineering genius of this country. Yet, that is the nation's new assignment today.

PRESENT LAWS HAMPER INDUSTRY

To undertake this new assignment, and engineers will, it appears reasonable that they and their associates in management should be fortified with such legislation as will give a fighting chance for success. They certainly must know the cost of labor and how much work will be obtained for what employees are being paid. They certainly must know in advance when their employees will work. They must be able to discharge those employees who will not work, and be allowed to employ some who will. They must be able to decide what work is to be done, how it is to be done, and when it is to be done. It must be possible to contract for raw materials at

ascertainable prices and for predictable delivery dates. The amount of taxes that will be required in payment must be known. There must be confidence in the predictability of the meaning of simple English words written as the law of the land. Today neither management nor its legal advisers, know for certain any of these prerequisites for the possibility of accomplishing the nation's vital assignment in production.

When the law of the land requires management to employ more employees than there is work to do, at wages, hours, and values of efficiency which the employees determine, then that law should be changed or management will not long survive.

When the law of the land permits one group of employees to compel other employees, by bodily force and threats upon their families, to pay a sizable sum of money each month to be allowed to work, and compels them to stop working or only do a limited amount of work, when they want to work, then that law must be changed.

When the law of the land permits a group of employees to compel another group of employees in a distant state, whom they do not know, to cease working for a management with which neither group has had any disagreement, then that law must be changed.

When the laws of the land are interpreted by the courts to be entirely different from the intention of the lawmakers, and at variance with the ordinary meaning of the language employed in the laws, then there must be some changes in the authority of our courts.

Today the nation is at long last conscious of many inequities that experience with laws directing business through the regulation of human relations has imposed upon our system of free enterprise. These inequities have placed that system in jeopardy to the extent that many are in doubt it will survive, unless those laws are modified constructively. In formulating such modifications in the laws affecting business, management must accept its responsibility to preserve the social benefits, such as unemployment insurance, old-age benefits, and free collective bargaining within the industry for which it is responsible; and to the extent the employees bargaining work under the direction of that management. Management first and foremost cannot fulfill its duties to its employees, to the consumers, to the investors, and to the nation in this coming crisis unless a contract resulting from collective bargaining is enforceable by the law of the land upon both management and employees alike. Management cannot expedite collective bargaining unless the law permits equal freedom in bargaining for both labor and management.

LAWS MUST BE INTERPRETED EQUABLY

The management of American business is not asking that many laws be repealed, or even modified. The astonishing interpretation by the courts of certain laws, and particularly the unreasonable and harsh administration of others, has produced such uncertainty and unpredictability in business, that management recognizes it cannot provide the jobs and the products at the prices necessary to preserve our economy and the system of free enterprise unless there are some constructive changes.

Business alone must provide the pay rolls and the products that will make a system of free enterprise work; and to provide these management must be able to compute costs with reasonable accuracy and sell at a profit. To preserve this right to operate business and know what pay rolls could be provided, several years ago, management initiated a campaign to revitalize the free-enterprise system. This was an attempt to educate the mass of the people on how the system worked, how it had been instrumental in the development of the country, and why it was the best in the world, so as to prevent any more untried economic theories from becoming the law of the land. That campaign was generally effective in making most of the people understand what was meant by "free enterprise," and in making the economists, the labor leaders, and the ordinary laborer, as well as our lawmakers, reaffirm their belief in the system and express their determination to preserve it. That campaign made it extremely unpopular to admit a belief in a different system of economy for this country.

FORCES AT WORK DESTROY FREE-ENTERPRISE SYSTEM

Today there are no open advocates to destroy the American system of free enterprise. However, the advancement of new economic theories, the spread of gossip, and the support of laws, which would destroy the system, continue uninterrupted, with each of the advocates proclaiming that such laws are necessary to preserve the system and make it work under the new and changed conditions. Such advocates enjoy calling themselves "liberals," and all who oppose them, "reactionaries." Strangely, each of these new theories and proposed laws finds some support among management who really think they are staunch and unfaltering believers in the system of free enterprise. This confusion within management arises from the new approach to change the system by segments, rather than in one operation.

For instance, during the serious days of last year's coal strike, which caused the steel plants to close down, resulting in making procurement of drill pipe and casing impossible, and oil-well contractors could not accept contracts for work, the author heard two such contractors suggest that the Government should take over and nationalize the coal-mining industry. These men were willing to have the other man's business taken over by the Government to eliminate a hardship, but it is sure they would not want the contracting business nationalized.

When last year it appeared that the railroads would cease operating because of a strike and every business was in jeopardy for lack of shipping, the author heard some successful businessmen say, "It looks like the Government will soon have to own the railroads to keep our economy going." The same men would certainly not want the Government to take over their businesses.

When Secretary of the Interior Krug stated in a public address last summer, "Our oil reserves are fast depleting, our discoveries are not keeping up with production, and for national safety we should stop using our oil and import from foreign sources of supply," none of the millions who use oil products raised a voice in protest, although there are 5,000,000 persons sustained by jobs provided by oil production in this country. None of the oil companies which own oil-producing properties in foreign countries protested, and some advocated producing less oil here and being permitted to import more, without paying taxes. Only those owners of oil-producing properties located exclusively in the United States protested Mr. Krug's theory, and they are now, through a system of educational propaganda, endeavoring to preserve their stake in free enterprise.

Last summer when packing plants were closed by strikes and meat was impossible to obtain, businessmen were heard to say the packing plants should be taken over by the Government; but they would denounce the Government taking over their business.

For some years the principal lender of government money has been the RFC, and some of its practices and unusual acts of favoritism are about to be investigated by the new Congress. To avoid this airing of "dirty linen," the Administration is now supporting a bill to emasculate the lending power of the RFC and center this privilege in the Federal Reserve Bank. Even

(*Continued on page 493*)

A UNIFORM CURRICULUM *in* MECHANICAL ENGINEERING

THREE papers discussing the current controversial topic "A Uniform Curriculum in Mechanical Engineering," were presented at an Education Committee session during the 1947 Spring Meeting of The American Society of Mechanical Engineers, held in Tulsa, Oklahoma.

EVOLUTION OF ENGINEERING CURRICULUMS

The first paper, by Charles W. Crawford, member A.S.M.E., head, mechanical engineering department, Agricultural and Mechanical College of Texas, College Station, Texas, discussed the growth of engineering education from the stage where it was largely a course in arts and sciences, with special emphasis on mathematics and physics, to the present highly specialized curriculums.

At first no department lines existed but as time went on and more was learned in various fields the idea of specialization grew up. This led to a few departments and later to many departments. As the body of knowledge grew in certain fields and as industries saw need for men with this knowledge, they asked for specialization. Certain phases of mechanical engineering illustrate this; for instance, petroleum and aeronautical engineering.

For some years, the mechanical engineering curriculum seemed to be based on the principle that to be worth while a subject must be practical or immediately usable. Courses in business correspondence and report writing replaced the more general courses in English.

The resentful attitude that the practical man had toward the college graduate resulted in the engineering educator shaping his curriculum so that his product would be the most acceptable to the employers. However, in the attempt to meet the demands for practical engineers, such courses as shop practices took a rather prominent place and skills became important. This took time from the more liberal courses and the basic science training suffered. The emphasis seemed to be on the "how."

After some years of this, the engineer was criticized for being narrow and uninformed. He did not know his scientific fundamentals as thoroughly as he should and his citizenship qualifications were not always adequate.

In the meantime, industry was making great advances and the knowledge in various scientific fields was developing apace. The educator found that he had more and more knowledge related to his particular field which he felt should be included.

As a result, less emphasis was placed on skill courses, even in drafting, and a more theoretical curriculum resulted. However, this still left little room for the humanistic-social training which was badly needed. In some schools, two years of preengineering work were required and in others, five-year courses were instituted.

At about this stage, World War II broke out. Engineers and industrialists worked wonders in production, but when new and hitherto unknown weapons involving unexplored scientific depths were needed, the research laboratories and the mathematics, physics, and chemistry departments of the colleges were turned to. Here men were found who were more thoroughly and more rigorously trained in the physical sciences and whose conceptions of the laws and fundamental principles were most complete. Their discoveries and developments startled the world.

Mechanical engineers, however, had a large part in putting some of the scientists' ideas to work, but, could they have made a larger contribution if their training in fundamental principles had been more thorough or had they specialized in certain phases of mechanical engineering and thus limited their usefulness?

Assume that specialization is both desirable and necessary. Such fields as internal-combustion engines, refrigeration, heating and ventilating, air conditioning, or steam power could not develop were it not for specialization. There are two ways in which this can be accomplished: Through the colleges and through industry. If colleges do the job, they must choose between graduate and undergraduate courses to accomplish their purpose. Even with a five-year curriculum and the necessity for increasing the time spent on humanistic-social courses, and more thorough grounding in the basic fundamentals in the scientific-technological field, there will be little room for specialization. The graduate year is designed for this purpose. Added depth and a better understanding of basic laws and principles is its chief aim. By this time the student should have decided upon his lifework.

If industry undertakes to do the specialized training for its mechanical engineers, we will have wide extremes. Some small companies have need for only a few engineers and they want men broadly trained who can do anything which needs to be done. In fact, such an organization may not have capable men to do the training. On the other hand, some of the large companies have thorough training courses consisting of both practical experience and rigorous theoretical courses. They are taking the long look and are trying to develop their engineers so that they can ultimately make the largest contribution of which they are capable.

In either case industry has a definite responsibility because the mechanical engineer who has taken a master's degree still must learn how the company for which he works conducts its business activities and how it can best make use of his particular services. Often the graduate is undecided about what he wants to do. He has little conception of how industry operates and how he will fit into the picture. In fact, many men who are only a few months away from graduation talk to representatives of various concerns and their decision may depend upon how good a selling job the representative did or upon how quickly he will get to return to a certain locality or the amount of pay offered. The nature of the work to be done or the long-time opportunities may be largely overlooked and any specialization which the student may have done will be of little value.

A technical elective or two may tend to focus a student's interest and thus cause him to work more diligently, but if such electives are based largely on fundamental theory, they can do no harm even if the student goes into another type of work.

If a reasonable balance is maintained in the mechanical-engineering curriculum and in the scientific technological courses, the maximum emphasis is placed upon laws and principles, and the "why" is continually kept uppermost rather than the "how," there will be little room in the undergraduate curriculum for specialization.

NEED FOR EDUCATION IN FUNDAMENTALS

In the second paper, Eugene F. Dawson, member A.S.M.E., director, school of Mechanical Engineering, University of Oklahoma, Norman, Okla., maintained that the mechanical-engineering curriculum should be made up largely of the subject matter which will supply the groundwork, fundamentals, and basic knowledge, both technical and nontechnical, for training the graduate to serve as a citizen and as a mechanical engineer.

The curriculum course content given at present in most engineering schools might be classified within the following three groups: (1) Humanities and social sciences, (2) pure physical sciences, such as chemistry, physics, and mathematics, and (3) engineering or applied physical science.

The fields of work open to the graduate mechanical engineer are many and varied; some of these are: Power generation, heating, air conditioning, refrigeration, automotive, aeronautics, transportation, inventing, sales, technical writing, railroad, petroleum, and heat-transfer engineering. In a particular field of work the mechanical engineer may find his duties to be under one of the following headings: Design, installation, operation, commercial, testing, engineering computations, equipment development, manufacturing, supervision, consulting, administrative, executive, and teaching.

A four, five, or even a seven-year program will not train men to be qualified to enter any one of the foregoing fields of work. It is a well-recognized fact that a graduate engineer has, in reality, just started his engineering education.

Industrial and research engineers, responsible for the training of new graduate engineers, want men of sound knowledge in engineering fundamentals who can think clearly and logically. The company will provide the necessary training for specialized work. The problem then is to build a curriculum which will provide fundamental mechanical-engineering education.

The curriculum in mechanical engineering at the University of Oklahoma, at present, is outlined for a four-year program, and may be divided into four groups approximately as follows:

Group 1	English, humanities and social sciences, physical education, and military science	25 per cent
Group 2	Mathematics, physics, and chemistry	25 per cent
Group 3	Engineering service courses such as engineering drawing, industrial engineering, mechanics, civil, and electrical engineering	25 per cent
Group 4	Basic and applied professional courses in mechanical engineering	25 per cent

All mechanical-engineering curriculums should have courses in all four of these groups, differing somewhat in percentage, however, for the four- and five-year program.

The geographical location of the school may be an influential factor in the elective applied courses. Curriculums, in schools in the Southwest, may be influenced by the petroleum industry and include more applied courses dealing with liquid and gaseous fuels, and the instrumentation, measurement, transmission, and storage of these fuels. Other geographical locations of the country may tend toward courses dealing with railroads, marine engineering, and manufacturing.

A certain amount of flexibility should exist in the curriculum course contents under the heading of technical electives. Courses that might come under this heading are: Motor applications, automotive engineering, fuels and lubricants, fuels and combustion, heating, air conditioning, refrigeration, heat transfer, advanced design, mechanical vibrations, instrumentation and measurement, metallography, manufacturing, and production engineering. These courses may be referred to as "specialized courses," but when available as electives in limited numbers they enable the student to try to specialize.

The young engineer needs a broad background of training in pure and applied science with just enough practical application to ease him into his professional career with a minimum of shock.

The goal of all education should be to produce graduates who think. Men in responsible positions who are interested in education are unanimous in their plea that fundamentals are important. They do not want technical specialization to hamper the student's ability to think along human engineering lines. A small amount of specialization in the senior year has merit; however, the greater amount of specialization should come in the postgraduate school and in the realm of industrial education in the postcollege days. The more general adoption of the five-year program may be the solution to a more uniform mechanical-engineering curriculum during the first four years.

TREND AWAY FROM SPECIALIZATION

Douglas Ragland, Humble Oil and Refining Company, Houston, Texas, who presented the third paper, declared that the curriculums for undergraduate mechanical engineers have become more or less specialized chiefly as the result of demands by various industrial interests for graduates with training to meet specific needs in a number of narrow fields of engineering. The resulting lack of uniformity in the curriculums has been at the sacrifice of thorough training in the fundamental sciences and humanities, since specialization has been accomplished without extending the training period.

Curriculums that are both uniform and thorough in their treatment of the natural sciences pertaining to engineering, the engineering sciences, and the basic principles of the nonphysical sciences and the humanities are necessary. While such a program definitely limits the degree of specialization that can be accomplished in undergraduate work, it still allows time for a moderate amount of attention to studies of applied engineering science in one of the major fields of engineering. A working example of a program of this sort is described in Harvard University's recent announcement of the opening of their School of Engineering Science and Applied Physics, which reads in part as follows:

> The four years of training in Harvard College are planned to provide the engineer or applied scientist with the fundamental sciences on which all technology rests. Almost two thirds of the undergraduate instruction is devoted to mathematics, physics, chemistry, and applied science. Specialization in the individual branches of engineering is deliberately postponed until the second half of the senior year. Then a choice among technical electives permits the program to be directed toward the chosen area of professional interest. Thus premature specialization is avoided so that the student may be more thoroughly grounded in fundamentals. Major emphasis is placed on the study of basic sciences, and illustrative examples are chosen freely from all branches of engineering and applied science.

Thus in the Harvard plan is found an undergraduate curriculum that meets the basic needs of industry, and should also meet with wide approval among educators and serve as a pattern for the development of uniform curriculums.

Some will postulate that in eliminating or seriously limiting specialization, we will end up not with mechanical engineers, or electrical engineers, or chemical engineers but with general engineers. In the four-year undergraduate curriculum, it well may be that this very result is to be desired.

The general engineer would have acquired a foundation in basic science that will enable him to choose professional work in any one or perhaps several of the fields of engineering. In many industries, the engineer must hold his own in several fields regardless of whether his education is general or highly specialized.

It is often said that the engineer or the mechanical engineer who lacks specialized training does not meet the needs of industries that have a definite place for specialists. One answer to this is obvious. Postgraduate courses in many fields of engineering are being offered by an increasing number of the engineering schools. While this system will not produce as many specialists as the four-year specialized curriculums, it will certainly produce better basically qualified specialists. The number may well be governed by the willingness of industry to pay a premium for a superior product.

Another answer is postgraduate study in the industry itself. Educators and industrialists alike recognize the value of such training.

All industries give their professional engineers on-the-job training in engineering. This training usually takes the form of learning while doing, but for the engineer who would be successful, it constitutes postgraduate study in every sense of the word. Less frequently, training by industry is offered on a formal basis, particularly where a high degre of especialization is desired. Notable examples of such formal training in the field of mechanical engineering are the mechanical-design school conducted by the Westinghouse Electric Corporation and the courses in advanced mechanical engineering incorporated in the Educational and Training Program of the General Electric Company. In the petroleum industry, formal training in applied reservoir engineering is being carried out on a small scale.

It is pointed out that size does not constitute the importance of the program. A single engineer in a small firm can train the few graduates which are employed. He needs only to have a genuine appreciation of his educational responsibilities in order to do the job as effectively as it could be done by an elaborate organization of educators.

The undergraduate curriculum which is almost exclusively science will produce scientists and not engineers. It will be held that such graduates do not feel the throb of industrial needs and therefore do not develop the desire to make a contribution toward their fulfillment. It is not the intention to strip the undergraduate of every opportunity to learn something of engineering practice while in school. Science courses for undergraduate engineers, as in the case of the Harvard curriculum, must embody the elements of engineering practice. The examples of application chosen for this purpose must be selected to develop in the student resourcefulness and judgment, an elementary competence in the engineering method. A newer approach is the adoption by the colleges of industrial-type personnel studies. Such studies are designed to introduce the student to industry and what industry expects of the graduate. The Texas A.&M. College inaugurated a program patterned along these lines in 1939 when the Office of Placement was established. Work of the office has proved highly valuable both to the student and to his prospective employer. Personnel analyses furnished by the director enable a prospective employer to make a sounder selection of graduates not merely to fill but to fit his needs. The student in turn acquires a familiarity with job opportunities in fields which rarely receive the consideration of graduates who are not so well informed. Many colleges conduct similar placement programs on a reduced scale through the office of the dean, registrar, or department head.

It seems that industry should insist that no sacrifice of fundamentals be made in undergraduate curriculums and that educators should more rapidly follow the recommendations of their own groups to design and place in effect a uniform undergraduate curriculum for mechanical engineers which will include the fundamental ideas, principles, and basic facts underlying the field and be limited largely to these and to materials involving their direct application.

Management's Responsibility for Constructive Legislation

(*Continued from page 490*)

the chairman of the Federal Reserve Board likes this plan and has identified his name with the new bill on which hearings were to be started this spring. Will many people protest? So long as there is a lending agency available, why should they worry about the name of it.

Well, the old propaganda is under way to gain support and dampen opposition. Now all the deposits in the Federal Reserve Bank belong to the member banks of this country and the U. S. Government. They are there to protect the banks of this country against closing when the depositors desire to withdraw their deposits faster than loans can be collected. If any considerable portion of the business of this country becomes indebted to the Federal Reserve Bank, and there should be a depression, those businesses would become owned by the Federal Reserve Bank just as the administration in power directed. The system of free enterprise could be destroyed forever by that simple process.

In the City of Tulsa we have a newspaper which professes to be a staunch defender of the system of free enterprise, and at the same time aggressively advocates the city of Tulsa taking over the Public Service Company by right of eminent domain. The author is confident that the paper in question would strenuously oppose the Government taking over the newspaper business.

From these examples, it is obvious the attack upon the system of American business is not open but devious, and so hidden that even the most sincere believers in the fundamentals of the system are innocently permitting its destruction without recognizing the manner in which it is being done. By propaganda, business is being persuaded that all this is an exception to the rule, only to take care of some special situation; and free enterprise is going to be preserved.

Recently, in Dallas, the author heard the editor of a large Texas newspaper open his address before a convention of bankers, with the statement: "In the coming revolution, you bankers will be the first to be shot," and "I think we newspaper people will be next, not because you have not provided a necessary function and done it well, but because the mass of the people will need money and your banks will have a lot of it."

ENGINEERS AND MANAGEMENT MUST DEMAND CONSTRUCTIVE LEGISLATION

A revolution arises when stomachs are empty because there are not enough jobs. The termination of all revolutions in modern times is a dictatorship. There must not be a revolution; but the only way to prevent it is to provide jobs for all who are willing to work; and only statesmanlike management assisted by the engineering genius of this country can perform this miracle under world economic conditions today. Lawmakers cannot make jobs. Economists can only tell what caused something to happen that has already happened.

Only the management of business and engineers, working together, can make continuing jobs and they must not fail. They have the first responsibility to use every sound argument, every persuasive appeal, every factual presentation, and an unbiased demand to cause constructive legislation, conducive to the operation of business to be adopted. Will they do it, as tired, discouraged, and ineffective as their efforts have been in the past? The author doesn't know the answer. But if all the things which we think should happen in our country fail within a few months after military victory, don't give up. We can and do make progress toward higher goals so long as we keep the goals clearly in mind.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Management and Engineers

WHAT does management expect of and from an engineer? A. C. Rubel, vice-president, Union Oil Company of California, answers this question in a paper which appears in the April, 1947, issue of *Mining and Metallurgy*. Although primarily concerned with the oil industry, Mr. Rubel's remarks apply to a large extent to other industries as well.

Management expects an engineer first to have a sound and fundamental educational background and then to learn his business both from the technical and the practical side. In the oil industry this can only be done properly by actually working in the various operations of the field or refinery as a regular employee and by earning, in competition with others, many of whom do not have the advantages of formal engineering education, the right to advance up the line.

It may be called an apprenticeship, a trainee program, or just plain experience, but most managements and most engineers who have served such a course will agree that without this experience in greater or lesser degree, an engineer cannot be of maximum value to his company.

Second, management looks on the young engineer, particularly, as the raw material from which the technical, much of the operating, and certainly no small part of the executive and managerial supervision of any company must be developed. Management should undertake to provide the means by which this material may be trained and developed along lines to which the individual is best suited and for which the company has most need.

Third, management expects the engineer, in addition to his technical and operative knowledge and skill, to learn the most difficult and perhaps the most important of all lessons in modern industry—human relations, the art of handling men. This art can never be learned in school or within the narrow confines of a technical organization, but only by experience in the field, by working with and for the men who make an industry go.

No matter what the technical or experience qualifications of a man may be, no matter if he be the best technician, the most versatile engineer, or the most skillful operator, his opportunities for advancement are decidedly limited if he cannot get along with men.

Fourth, management expects the engineer to work. Neither the job of engineering, operating supervision, or executive management can be successfully handled in an eight-hour day or a five-day week. Scheduled time applies to routine operations and likewise scheduled operations apply to routine men.

Fifth, management expects the engineer to learn to think—to think independently and originally, and not in "quotes." This is likewise a tough assignment and not everyone, by any means, can master it. This is particularly true in the oil business. In no other industry or business is so little actually known about the fundamentals of the work being done, about the complexities of reservoir behavior, the effect of various completion practices on subsequent production, the difficulties of well correlation, and the many everyday problems affecting even routine operations. There is correspondingly almost unlimited room for original thinking and new ideas to be explored and developed.

It is highly desirable for the engineer to keep up to date on contemporary technical literature but it should be a basic part of his philosophy to take nothing for granted and to scrutinize, in the critical light of his own knowledge and experience however limited that may be, every conclusion developed, no matter how celebrated the authority or well known the publication, before adopting it as his own.

An engineer should be an active member of one or more technical societies in the fields of his chosen interests. He should participate in their discussions and contribute to their literature if there are worth-while subjects upon which to write. Management will usually encourage this with time and facilities.

Sixth, an engineer, and particularly a younger one, is expected to do a certain amount of crabbing and bellyaching and to feel a bit abused and unappreciated at times, but he is also expected to do something about it, not just be content with the luxury of crabbing. Nothing is more stimulating to management than constructive criticism or dissatisfaction with current practices and results but there is nothing worse than that same criticism, even though it be constructive in its inception, unless it be followed by action by the critic in an attempt to remedy the supposed faults. Supervisors are, as a rule, busy men, occupied with their own problems. Unless they are unusually responsive, the natural reaction to any new idea is negative or at least a new idea is viewed with skepticism. This is perfectly natural. It is up to the engineer either to put over his idea by demonstrating its merits or to find out the reason why it is not acceptable.

Seventh, management expects an engineer to assume his duties and responsibilities as a citizen, to take an interest in the political, social, and civic affairs of his community. Technical and scientific developments are far outstripping the political and social ability to absorb or utilize them, or in fact, as witness the developments in nuclear physics, to even control them. Of what use is technical development if we cannot apply it for the benefit and not the destruction of mankind? Politicians, statesmen, lawmakers, soldiers, and past and present leaders of business and industry have proved rather conclusively their inability to adapt our society and our economy on a national scale to technological advances. The engineer is one of our remaining hopes. He is a student of natural laws. If he can adjust politics and statesmanship to these laws instead of going completely contrary to them as we are now in many instances doing, then and only then may we expect to reach some limited degree of peace and continued prosperity in our country and in the world.

Eighth, management believes in and wants the engineer as an integral part of that management, and as such he must give it his undivided support and loyalty. There can be no room for a union, collective-bargaining agency, or any other alienating

influence under such an arrangement. Modern trade unionism has as its fundamental basis the objective of gaining security for its members. It accomplishes this at the expense of opportunity and freedom for the individual. It reduces its members to a common denominator. A bricklayer is a bricklayer in modern trade unionism and draws a bricklayer's pay whether he can lay 400 or 1200 bricks in a day. In many instances the man's production is completely controlled by the union itself so the best man of the group is geared to the pace of the poorest. An engineering union must eventually come to a similar result. This violates every basic principle of the profession.

Unions may serve a necessary purpose among certain men but an engineer must be far more concerned with opportunity than with regimented security. An engineer's creative thinking cannot be regimented, or his efforts or working hours prescribed and limited, without reducing him to that drab status of a routine technician with artificially limited creative opportunity and little or no incentive.

Ninth, management expects the engineer to be adequately compensated for his job. How this compensation is determined varies greatly within the industry, and the adequacy of the pay is likewise a function of the personal thinking of the recipient.

Comparisons are difficult between the man who develops a plan and the man who executes it; the development engineer and the drilling superintendent, the production engineer and the production superintendent, the designer and the builder. Who can say which contributes the most to the production of oil?

To arrive at relative compensation the method is simply to make the best possible comparative analysis of jobs. The engineer himself, if he is honest, can see the answer.

John Suman, as vice-president of the Humble Oil and Refining Company, is reported to have evolved a standardized summation for all young engineers entering the services of that company. He said to them, "Your job is to get my job." This is the best summary management can make of what it expects of engineers.

Helicopter Instrumentation

THE limitations of the helicopter, namely, difficulty in control, low forward speed, relatively poor performance at high altitudes, and limitation of load and range, have been the subject of much discussion. It has been estimated that by 1954 helicopters might become sufficiently simplified to be made available for more general public use. Instrumentation may assist in overcoming some of these difficulties.

Many of the instruments used in helicopters are standard aircraft instruments, while others are designed especially to meet the needs of the helicopter's peculiar flying characteristics. Those instruments which are not standard were discussed by C. F. Savage and R. G. Jewell, General Electric Company, West Lynn, Mass., in a paper which they presented at an Aviation Division–Industrial Instruments and Regulators Division technical session held during the June, 1946, A.S.M.E. Aviation Meeting in Los Angeles, Calif.

TACHOMETER

The speeds of the engine and of the rotor are not always of a fixed ratio as is the ratio of engine to propeller speed in the airplane. The rotor of the helicopter is connected by means of a clutch to the engine and is brought up to a fixed ratio to engine speed when the clutch is fully engaged.

An electric tachometer system with a dual concentric indicator is used. This is the common aircraft type having an alternating-current generator used as the transmitter and a synchronous motor driving a magnetic-drag tachometer as the indicator. One element is driven by a generator geared to the rotor; the other by a generator geared directly to the engine. One is calibrated for engine revolutions and the other for rotor revolutions. The scales are so arranged that the pointers move coincidentally without slippage and are in direct alignment when the rotor and engine are operating together. This instrument has worked out satisfactorily. An improvement which might be added is a contact-making device that would sound an alarm if the rotor speed approached the danger point. This would be of particular value during an emergency dead-engine landing, at which time the pilot has little time to watch the rotor speed indicator.

AIR-SPEED INDICATOR

Helicopters can fly at much lower speeds than airplanes and it is desirable to obtain air-speed readings at these low values. The pressure from the Pitot head varies approximately as the square of the air speed, and hence at low speeds very little pressure is available for instrument operation. At 5 mph this pressure has a value of around 0.012 in. water, whereas at 100 mph the value is $4^3/_4$ in. water. An indicator made for this application has a sensitive arrangement giving air-speed indications from 10 to 150 mph.

The location of the Pitot static tube on conventional airplanes is such that the air flow is not disturbed by the slip stream from the propeller. The Pitot static tube is rigidly attached and is pointed in the direction of flight. It is moré difficult to locate the Pitot static tube on a helicopter because the rotor causes a downward flow of air all around the craft. A conventional location is near the rotor axis, between the top of the cabin and the plane of the rotor. This position cannot be considered ideal since the downwash in forward flight is not zero in the center and comes in puffs as each rotor blade in passing causes oscillations in the pressures being measured.

Another difficulty with this arrangement is that the speed is correct only when the craft is flying in a direction parallel to the fore and aft axis of the craft. Also, when the craft has forward motion only, the axis of the craft deviates from the horizontal and this deviation becomes larger as the forward speed is increased. This causes the Pitot tube to point downward and the static tube to be exposed to dynamic pressures, thus making the indicated speed less than the actual speed. Each design of a helicopter requires tests to determine where best to locate the Pitot tube and calibrations can be made which give reasonably good indications. Since lift does not depend on forward speed in the case of the helicopter, use of the Pitot static type of air-speed indicator is neither essential nor necessarily desirable. Some consideration is being given to the true air-speed indicator of the rotating-element type.

PITCH INDICATOR

The main rotor has two pitch controls—one called the collective pitch which controls lift; the other the cyclic pitch which controls the attitude of the craft, and hence its direction of motion. The pitch indicator which has been used on some of the earlier designs is coupled mechanically to the collective pitch control and indicates only the collective pitch setting.

This indication is used to give an approximate setting of collective pitch for proper co-ordination with engine speed at take-off. It is also used to insure proper pitch setting for the autorotation during emergency power-off landings. The total range of pitch indication is $2^1/_2$ to 13 deg. The construction of this device is simple. The pointer is mechanically coupled to the pitch control by means of a flexible cable.

AZIMUTH INDICATION

Direct-reading compasses are used for azimuth indication

There are complications however, since the index mark (or lubber line) is tied to the craft and is aligned with the fore and aft axis, which frequently does not coincide with the direction of flight. Inasmuch as the helicopter can move laterally without moving ahead, the information obtained from the compass could be in error by 90 deg. In fact, if the craft is flying backward, the error would be 180 deg.

One solution would be to use a lateral-motion indicator such as a yawmeter or a "flight path indicator" and to read the compass only when the lateral-motion indicator reads zero and the forward air-speed indicator has an indication above zero. Under these conditions, the direction of flight through the air would be properly indicated by the compass. Drift due to a cross wind can then be calculated in the conventional manner.

Another scheme which has been used to indicate motion laterally is a differential air-speed indicator operating on the difference in pressure between two Pitot tubes, one of which is pointed to the right and the other to the left. When zero indication is obtained there is no motion laterally. The trouble with this scheme is the difficulty encountered in locating the two Pitot tubes so that the Pitot pressures will be properly balanced.

A third instrument that is proposed is a simple pendulous bank indicator. The helicopter fuselage acts like a pendulum. When hovering, the fuselage hangs approximately vertical; when there is motion in a given direction, the whole craft tilts. Therefore any lateral motion would be indicated on a pendulous bank indicator.

GYRO HORIZON

The gyro horizon installed in a conventional airplane is a reference for maintaining level flight. A slight adjustment of the pitch reference index to suit the load of the airplane makes it possible for the pilot to fly a level course.

The gyro horizon installed in a helicopter may indicate no pitch, whether the craft is gaining or losing altitude in cases of vertical ascent or descent. An indication of dive results when the craft has forward motion even though the altitude is held constant. Thus the indications of the gyro horizon in the helicopter have an entirely different meaning from those in the conventional airplane.

An indication of bank on the gyro horizon in the helicopter means that the craft is moving laterally. This, then, might be a good means of controlling the craft so that no lateral motion exists.

AUTOPILOTS

An automatic control for any device is easy to design if the device to be controlled has inherent stability. The problem becomes more and more difficult as the device becomes more unstable. On the other hand, the more unstable a device is the greater is the need for automatic control.

The requirements of an autopilot are that it should maintain the desired direction, speed, and altitude of flight. To fulfill these requirements the controlling instruments necessary are a gyro horizon, a directional gyro, an altimeter, and an engine speed governor.

The gyro horizon requires a control pick-off on the bank axis to control the lateral motion of the helicopter. The gyro would be provided with adjustments, so that zero bank could be maintained automatically and under this condition the fuselage would be pointed in the direction of flight. The controlled element would be that cyclic-pitch axis of the rotor which controls lateral motion. The pick-off on the pitch axis of the gyro horizon would be used to control that cyclic pitch which governs forward motion. This control would be adjustable so that a given pitch would be maintained and this would maintain the desired forward speed.

Since the gyro horizon maintains a zero lateral speed, the directional gyro indication is true. A control pick-off on the directional gyro would control the pitch of the countertorque propeller on the tail of the craft and this would control the direction of flight.

The altitude of flight for a given load is determined by the rotor speed and collective pitch. Neither the gyro horizon nor the directional gyro can be used for altitude control. A control pick-off on the altimeter is required. This can be used to control the collective pitch of the rotor and a governor can be used to maintain engine speed.

It is realized that an unstable helicopter presents a problem in designing a suitable automatic pilot, but in view of present-day knowledge of automatic control, a solution to the problem appears to be possible.

High-Altitude Photography

AN aerial photograph of the earth, Fig. 1, taken at an altitude of 100 miles—far higher than any other photograph has ever been taken—shows the earth's curvature and more than 200,000 square miles of the United States and Mexico. The camera was part of more than 2000 pounds of scientific equipment installed by scientists of the Naval Research Laboratory, Washington, D. C., in a V-2 rocket launched March 7, 1947, at White Sands Proving Ground, New Mexico. The distance from the curved horizon at top of the picture to the point directly under the rocket, at bottom of the picture, is about 900 miles. The dark body of water, near top of picture, is the Gulf of California, about 65 miles wide. The picture also shows rivers, islands in the Gulf of California, the peninsula of Lower California, part of the Pacific Ocean, and other landmarks. Clouds form the white mass along the horizon at top of picture. San Diego is just out of sight at top right of picture.

FIG. 1 SURFACE OF THE EARTH PHOTOGRAPHED FROM AN ALTITUDE OF 100 MILES.

Two aerial cameras were installed amidship in the rocket. They operated automatically, taking pictures through an infrared filter used to cut the haze. To overcome the difficult problem of recovering photographic and other equipment, since the rocket lands with enough force to blast a hole in the ground 40 ft deep and 80 ft across, the nose and tail of the rocket used in this flight were blown off by explosives detonated by radio signals. Because most of the information gathered by the instruments during the flight is radioed back to observers, the photographic films are the most important recoverable objects. Search parties spent several days in locating the cameras and other equipment scattered over several square miles of desert. In this instance most of the equipment fell in open desert rather than in scrub growth where it would be difficult to locate.

The spectrograph which photographed the sun's spectrum also was recovered, and scientists of the Naval Research Laboratory are now studying the spectrogram films of the sun taken at an altitude of 100 miles. The Navy and Army are co-operating on the V-2 flights for scientific purposes. The Naval Research Laboratory is conducting upper-atmosphere research for the Navy. This particular rocket flight was successful in gathering valuable new information in the fields of upper atmospheric pressures and temperatures, cosmic rays, ionosphere investigation, and studies of solar spectra. The rocket reached an altitude of 100 miles and traveled 36 miles north of its launching point. The time of flight from launching to the break-up of the rocket was 6 $^1/_2$ minutes.

Miniature Motors

TECHNICAL specifications for miniature motors (two watts and under) developed in Germany during the war, are described in a report (PB 42770) on sale by the Office of Technical Services, Department of Commerce, Washington 25, D. C.

The motors were made by the Contessa Works of the Zeiss Ikon Company at Stuttgart. They were of the single-phase induction type, with a separate capacitor starting winding.

One model of the motor is 1 $^1/_4$ in. long and $^3/_4$ in. in diameter. It consists of a laminated wound stator and an aluminum rotor mounted on a steel shaft running in sapphire bearings. The outer casing is a die casting with circular laminated iron stampings. A small transmission gear on the end of the rotor shaft projects through the casing.

Starting the motor requires a voltage of 36 volts, 500 cycles, and a current of 110 to 135 milliamperes. Once started, it uses only 55 to 65 milliamperes at 30 volts (1.65 to 1.95 watts). Its speed is 15,000 rpm.

Portable Arc-Welding Unit

AN inert-gas metal arc-welding unit for welding aluminum has been constructed by the Aluminum Company of America. Although not intended for outdoor use, the unit is mounted on a road-type trailer to facilitate transportation.

The portable welding unit was specifically built for welding aluminum electrical conductors during construction and assembly operations, but it is readily adaptable for joining aluminum tubing, extrusions, and sheet up to $^1/_4$ in. The inert-gas metal arc process was selected for making these joints because no welding flux is needed.

This welding process for aluminum consists of drawing an alternating-current arc between a tungsten electrode and the aluminum to be welded. The electrode and the molten-aluminum weld-pool are protected from oxidation by an envelope of argon gas which is inert to both materials and practically insoluble in aluminum. The high-heat intensity of the electric arc permits the joints to be made quickly with a minimum of heating. Both the welding torch and its power cable are water-cooled.

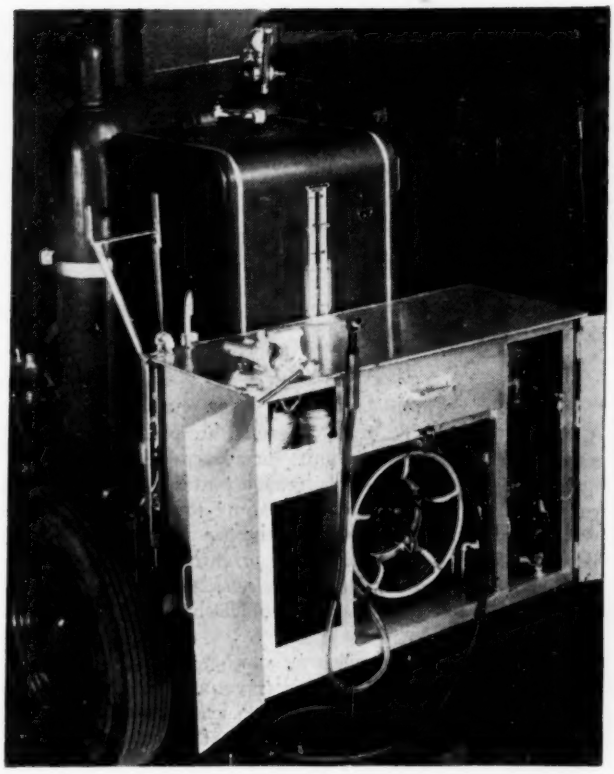


FIG. 2 PORTABLE INERT-GAS METAL ARC-WELDING UNIT

The three-wheel unit carries the welding transformer, cylinders of argon gas, and connections for the water and drain lines. Electrical control provides protection of the torch against failure of water supply and also starts and stops the argon gas flow and power to the torch.

Torch leads, 25 ft in length with a 50-ft extension, permit welding in positions and places usually considered almost inaccessible.

The unit requires a source of about 20 kva of 440 or 220-volt, 60-cycle power, and a source of clear cool water of $^1/_2$ gpm at 50 psi.

Airport-Approach Light System

A NEW all-weather airport-approach light system has been developed by the Westinghouse Electric Corporation, that is visible through 1000 ft of the thickest weather, when objects 50 ft away cannot be seen in daytime. The system includes flash units that will give up to 3,300,000,000 peak beam candlepower for use in zero-zero visibility and blaze units that are controllable so they can be set to emit a soft red glow of about 100 candlepower for use on clear moonless nights. Between these two extremes are steps of candlepower suitable for any intermediate weather conditions.

Preliminary tests at Cleveland Municipal Airport have proved that the bad-weather problem of disrupted schedules and endangered lives and planes can be practically eliminated at airports where this new system is installed. These tests have shown that the transition from instrument approach to visual landings can be accomplished easily under any condition of fog.

The tremendous range of candlepower permits all approaches to be made during any kind of weather, day or night, so that full instrument procedure becomes routine and bad weather introduces no new problems.

The system requires no additional equipment on the plane. It works equally well with any type of instrument approach system: instrument-landing system (ILS), ground-controlled approach (GCA), or microwave. It is said to be the first system of lights with enough power to be of use in foggy daytime and with characteristics that cannot be mistaken for any other type of light.

The complete system consists of approach lights, runway designator, and runway lights.

APPROACH LIGHTS

Thirty-six krypton flash units, each with a brilliancy of 3,300,000,000 peak beam candlepower, are placed in line alternately with 36 neon blaze units for a distance of almost three quarters of a mile from the approach portal to the start of the runway. The krypton lamps are only four inches long, but when a surge of electricity heats the gas to incandescence, the lamp flashes with a maximum brightness of nine million candlepower per square inch. The reflector and optical system of the lighting fixture magnifies this flash to three and a third billion candlepower.

When flashed rapidly one after another, the line of lamps appears like a stroke of lightning traveling toward the airport landing strips. Flashing forty times per minute, this line of vivid light can be seen for at least 1000 ft even in zero-zero visibility.

In clearer weather, intensity of the approach lights is reduced, and the krypton units can be turned off in favor of the less brilliant neon blaze units that can be used as either flashing or steady-burning lamps. Brilliance of the neon units can be reduced to as little as 100 candlepower on clear nights.

RUNWAY DESIGNATION

An 83-ft combination red cross or green arrow serves to direct runway traffic. As the pilot approaches the beginning of the runway, he sees on the ground a brilliant green arrow 83 ft long, indicating that the runway is all clear for his landing. This is called the runway designator. If for some reason the runway is not clear, the designator is changed to a high flashing red cross. The arrow and cross are formed by green zeon or red neon tubular lamps.

RUNWAY LIGHTS

New powerful runway lights will give the pilot an accurate picture of the runway's width and direction. These new, high-intensity runway lights are spaced at 200-ft intervals along the runway border. Each light can cast a steady penetrating beam of 100,000 candlepower intensity—about 100 times brighter than the runway lights now in commercial use. Although 100,000 candlepower can be used in worst visibility conditions, brightness can be reduced gradually to five candlepower for clear night operation.

APPROACH-ANGLE INDICATORS

To help make foggy-weather landings routine for pilots, two approach-angle indicators are installed near the head of the runway. These tell pilots in clear weather that they are coming in at exactly the right altitude for a perfect landing. Projecting a tricolor beam, sharply divided into horizontal layers, these indicators appear as flashing yellow lights if the plane is too high, red if it is too low, and green when the rate of descent is correct.

It is said that this positive means of getting an airplane to the ground safely once the pilot has been directed to the airport by radio means will cut accidents 90 per cent by preventing airplane crashes now caused by poor visibility in landing. Poor visibility will no longer be reason for canceling or delaying a scheduled flight to airports equipped with these landing aids.

Records of the Civil Aeronautics Board indicate that during the year 1946, nineteen air crashes caused by poor landing visibility occurred during commercial flights of United States airlines that could have been prevented by this new all-weather lighting system.

Carbon-Monoxide Indicator

A CARBON-MONOXIDE indicator, said to be the most sensitive instrument of its kind, used for the rapid determination of infinitesimal amounts of carbon monoxide in the air, was developed by the National Bureau of Standards during the war. The detector is about the size of a pencil and was used extensively during the war to detect poisonous fumes in plane cockpits and tanks. The indicator will detect and closely estimate less than 1 part of carbon monoxide per 500 million parts of air, which allows a big safety factor because it takes about one part of carbon monoxide in 10,000 parts of air to affect the human system.

The detector consists of a small glass tube, sealed at both ends, and a rubber bulb all packed into a small kit that fits into the pocket. When the presence of monoxide is suspected the kit can be opened, the tip broken off a small tube, and one end inserted in the bulb to draw air samples through the chemicals in the tube.

If carbon monoxide is present the yellow chemicals will turn green in thirty seconds. The darker the shade of green, the higher the monoxide concentration. A matching color chart tells how high the concentration is.

This new indicator can possibly be used in cockpits and cabins of airplanes, in cabins of gasoline-propelled boats, in buses and cabs of motor transports, in automobile repair shops, refineries, mines, homes, private automobiles, or wherever carbon-monoxide fumes might be expected. The United States Safety Service Company, Kansas City, Mo., has been licensed by the government to manufacture the gels and instrument and will be in production on the item within the next few months.

All-Aluminum Ships

THE construction of two all-aluminum merchant vessels, the first in maritime history, may become a reality before many months, according to an article in the *Aluminum Bulletin*, March, 1947. The proposed ships, scheduled for Caribbean runs by the Alcoa Steamship Company, will be built of aluminum alloys from bow to stern.

General characteristics of the first of the vessels are: 422 ft long over-all; 60 ft extreme beam; 10,232 tons displacement; cargo-carrying capacity, 8143 tons; maximum draft, 20 ft. Somewhat smaller, the second carrier will displace 6730 tons, have an over-all length of 348 ft, a beam of 54 ft, and a 19-ft draft. Her cargo-carrying capacity is rated at 5101 tons. Use of aluminum alloys will permit the ships to carry some 20 per cent more cargo than similar-sized ships of other materials.

Although aluminum has long been used extensively in ships' superstructures, topside equipment, and related installations, this will mark an important "first" in hull construction. Moreover, the lightweight metal will be employed in superstructures, funnels, lifeboats, and davits. Bulkheads, hatch covers, and

miscellaneous fittings will be formed of aluminum, as will the furnishings in all living quarters.

Playing a large part in the decision to build the ships will be the results of an intensive study of the *Alumette*, an all-aluminum hull which for more than eleven years has been moored at Newport News, Va.

Designed for the Aluminum Company of America, *Alumette* represents that portion of a ship's hull which would remain if the forward and after sections had been chopped off adjacent to the two watertight bulkheads. Full scale, she would have been a 100-ft high-speed patrol boat. Her dimensions are 13 ft, 10 in. in length; 10 ft, 0 in. beam; 5 ft, 0 in. depth; 2 ft, 4⅝ in. draft.

Structural parts of the hull were treated with zinc-chromate iron-oxide primer; when assembly was complete, the entire hull, inside and out, was given a second coat of the primer. Her underbody was painted with one coat of dark-red antifouling paint, and her exterior was finished with two coats of Navy gray enamel. The bilge was treated to a final coat of hot bituminous compound and two coats of aluminum Bakelite varnish were applied to the entire interior.

Since then, several paint systems have been tried; the one found best for the hull consists of one coat of zinc-chromate primer followed by one coat of antifouling paint.

Alumette was launched on Dec. 16, 1935, at Bath, Me., and was subsequently shipped to Newport News where she was placed in open water a month later to begin her experimental existence. Inspected twelve times in the past eleven years, *Alumette* today is as sound and shipshape as she was back in the forming shop at Bath.

After being exposed to unstinted attack by sea water and marine organisms for more than eleven years, *Alumette* has proved that: Wrought and cast alloys of the aluminum-magnesium type are entirely suitable for the construction of ships' hulls both from the standpoint of fabrication and resistance to attack by sea water; the alloys are not affected by any known type of marine growth; electrolytic attack can be effectively eliminated by proper insulation of the parts or by protective zincs.

She has spent less than four months—constituting brief periods for inspection and reconditioning—in the dry dock. She has been buffeted by harbor ice, torn from her moorings by storms, and bared her underbody to the worst that Hampton Roads' marine varmints could offer.

Undergrate Air Distributor

A NEW device known as an "undergrate air distributor" for railroad steam locomotives was announced recently by Bituminous Coal Research, Inc., at a meeting of its Motive Power Committee held at Battelle Memorial Institute.

This device increases the efficiency of burning coal in the steam locomotive by improving the distribution of undergrate air for combustion. With uniform air flow to the fuel bed, excessive losses of unburned coal out the stack are avoided and the value of bituminous coal as a locomotive fuel is increased. Road tests, it was reported, indicate fuel savings of from 7 to 15 per cent, depending on the speed of the locomotive. Another important advantage claimed is a reduction in clinkering, which lowers maintenance cost and increases the availability of the locomotive.

Vaughn Mansfield, chief engineer, Southern Coal Co. Inc., Memphis, Tenn., who invented the undergrate air distributor, explained that every pound of coal burned in a steam locomotive requires 15 times its weight of air for combustion. Passing this great volume of air uniformly through the fuel bed, as is done with this new device, is said to prevent channels of high-velocity gas that entrain cinders and unburned coal.

The undergrate air distributor is composed of parallel airflow baffles, or vanes, which are attached to the locomotive firebox where the air enters the ashpan. The baffle unit may be installed at the nominal cost of a few hundred dollars, depending on the locomotive construction and the number of engines being equipped. Road tests indicate an annual saving of several thousand dollars per year for each locomotive, depending on the type of service and the amount of coal consumed. Because of a reduction in clinkers, the engine operates with more freedom from trouble, and the fireman's labors are greatly reduced.

Also, efficient combustion results in less coal consumption, so that fewer cars and locomotives will be required by the railroads to transport their own fuel.

Thorough road testing has been done by the Louisville & Nashville Railroad, and the Illinois Central Railroad is now engaged in similar tests. Many steam locomotives of the Canadian Pacific Railway are equipped with the undergrate air distributor. Thorough proving on 4000 miles of main-line service of a Canadian Pacific locomotive indicated a substantial saving in coal was attained. The Canadian National Railways also have given it extensive road trials.

The undergrate air distributor will be supplied by the Standard Stoker Co., Erie, Pa.

Atomic-Powered Ramjet

AUTHORITATIVE and little known facts of the application of atomic energy to the problem of interplanetary flight are revealed in *The Cornell Engineer*, April, 1947, in an article entitled "Next Step—Space," by Alvin L. Feldman, a student member of A.S.M.E. attending Cornell University. Besides discussing take-off, landing, and navigation in space, the article includes an account of the atomic-powered ramjet conceived at Los Alamos by Dr. Richard P. Feynman of the Cornell University physics department. Dr. Feynman's principle is protected by patents.

The ramjet is an air-stream engine, sometimes referred to as a "continuous-duct" engine, though it is now becoming familiar under the British name "athodyd."

When the ramjet moves forward at about the speed of sound, the air rammed into the open forward end expands in the combustion chamber where it is highly heated with gasoline or other fuel to produce an accelerated movement toward the rear and out the nozzle. The ramjet needs no moving parts whatever for its operation but it does not approach any worth-while efficiency until it reaches a sonic velocity.

The atomic-powered ramjet as proposed by Dr. Feynman, instead of burning a combustible fuel such as gasoline or kerosene, would derive its heat energy from rods of a fissionable material such as uranium or plutonium.

These rods would not be of pure uranium but would be a mixture of beryllium oxide and uranium, the purpose of the beryllium oxide being to make the uranium a refractory substance and to prevent it from oxidizing to the stage where it would start peeling and melting. No generating equipment is needed to start the fission of the uranium because as soon as it is installed fission begins. When fission occurs in uranium or plutonium it can be assumed that two neutrons are emitted. These two move about until they come in contact with atoms of uranium, at which time they cause the emission of two more neutrons from each of the atoms. This continues to occur and, if left uncontrolled too long, would result in a chain reaction of great magnitude, probably causing a dangerous explosion.

To prevent the chain reaction from advancing too far, use is made of boron rods which have the property of absorbing neutrons. The number of neutrons to be absorbed by the boron can then be controlled by the amount that the boron is inserted into the heating chamber of the ramjet. Because of leakage, in actuality only about half of the neutrons that are emitted cause fission, but three fourths of one per cent are delayed about ten seconds, and these are the ones that are controlled by the boron. Naturally, in order to have a steady state of energy produced, the thing to do would be to insert the boron to a depth such that it would exactly absorb enough neutrons to bring the loss because of leakage up to 50 per cent. Therefore the number of neutrons in the chamber would be kept fairly constant inasmuch as every time two new neutrons were produced one of these would be lost because of leakage, leaving the total the same as it was before. If more boron were placed in the chamber, the result would be that more neutrons would be absorbed, leaving fewer neutrons wandering around to cause fission. If this were done, the effect would be to leave a smaller available percentage of free neutrons, bringing it from, say, 50 per cent to 49 per cent. This would have the effect of causing a gradual decrease in the heat energy released.

If the operation were to be reversed, the percentage might, for example, rise from 50 per cent to 51 per cent. In this case there would be a gradual increase in the amount of heat energy. By sensitive adjustment of the setting of the boron the energy output of the uranium can be controlled to an exceptional degree. It should be noted that although only three fourths of one per cent of the neutrons emitted are immediately controlled by the boron, this is quite enough to control the balance of the reaction and therefore the direction of the changes in energy output.

In a ramjet of this type the control of the boron would be of the utmost importance because, if the amount decreased very rapidly, there would appear an immediate increase in the number of neutrons which would probably result in a chain reaction of great magnitude. To avoid an occurrence of this nature the likely thing to do would be to insert in the chamber a form of thermocouple or thermostat which would automatically control the setting of the boron so as to keep the magnitude in the desired range.

The advantage of this atomic-powered ramjet is self-evident when it is realized that one gram of uranium will provide the heat energy equivalent to the burning of 358,000,000 lb of Pennsylvania anthracite coal.

Miniature Rolling Mill

A MINIATURE Sendzimir precision cold-strip mill is now rolling "Hiperco," a new magnetic alloy, for experimental use at the Westinghouse Research Laboratories. This rolling mill stands less than the height of a man and is about as wide as an office desk. Each part of the delicately balanced roll mechanism is ground to an accuracy of $^1/_{10,000}$ in. to assure precision in rolling metal to $^1/_{2000}$ in. thick.

The two rolls that do the work measure less than half an inch in diameter giving forty times more compression than would the larger rolls of ordinary mills. In operation, a 100-ft length of metal $^1/_{40}$ in. thick is fed into the mill at speeds up to 200 ft per min. The material being worked is wound on 12-in. reels on each side of the working rolls and is passed back and forth seven times before it reaches the desired $^1/_{2000}$ in. A Westinghouse Rototrol Regulator maintains the proper tension on the strip. The mill itself was designed for the Westinghouse Research Laboratories by the Armzen Company of Middletown, Ohio. The new magnetic alloy, a combination of 35 per cent cobalt, 64 per cent iron, and 1 per cent chromium alloy, is described in an article on page 319 of the April, 1947, issue of MECHANICAL ENGINEERING.

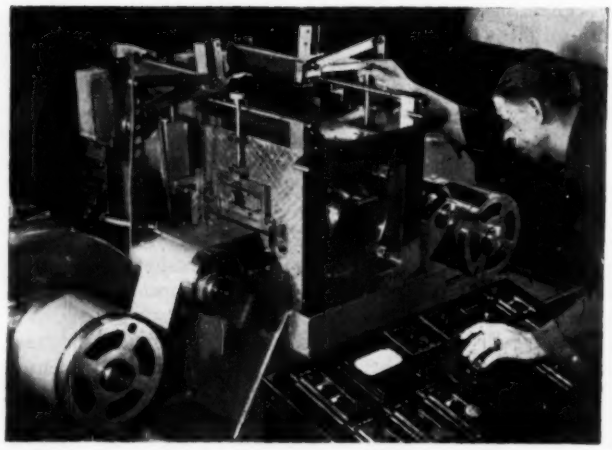


FIG. 3 MINIATURE ROLLING MILL

Boiler-Tube Corrosion

AN analysis of the causes of corrosion experienced with metals used for steam-generating tubes and superheater tubes in high-pressure boilers, and some recommendations as to what can be done to overcome this problem, were presented April 12, 1947, in a paper delivered before the Louisville Congress of the Electro-Chemical Society by Paul M. Brister, staff engineer, and J. B. Romer, chief chemist, of The Babcock and Wilcox Company, New York, N. Y.

A type of corrosion that has been quite serious, although not prevalent, in carbon-steel tubes in high-pressure boilers was described. This corrosion appears in the form of intergranular disintegration of the metal adjacent to a pit that is filled with iron oxide. Usually, deposits of metallic copper and oxides of copper are present in the zone affected by corrosion, but metallic copper is often found in boilers that are not troubled by corrosion. Dissolved ammonia in the boiler feedwater can bring copper into the boiler, provided there are materials containing copper in the system with which the feedwater comes in contact.

In presenting an analysis of this type of corrosion, the authors discussed all conditions associated with the failures and stated that the principal relief from this corrosion has come from: Eliminating or reducing as much as possible the ammonia in the feedwater-steam system; maintaining the boiler water at a satisfactory alkalinity or pH level; reducing the dissolved oxygen in the feedwater to as near zero as possible; and maintaining a small but positive excess of sulphite in the boiler water.

After discussing several theories that have been proposed to account for this type of failure, the following summarized explanation was offered:

1 The role of ammonia is primarily that of a vehicle which transfers the copper from heat-exchanging equipment to the boiler.

2 In the absence of dissolved oxygen, a film of iron oxide forms as a result of the iron-steam reaction. This film, if not damaged, stops further attack; if damaged, it re-forms and considerable metal may be converted to the oxide. The structure of this oxide is such that the hydrogen, simultaneously

formed, is able to escape into the water-steam mixture and intergranular attack does not occur.

3 Dissolved oxygen creates pits filled with hard barnacles of black oxide of iron. This reaction does not liberate hydrogen.

4 When the combination of ammonia, copper, and oxygen exists then there is at least one additional factor involved, namely a galvanic couple which creates an anodic condition beneath the barnacles, causing corrosion of the metal; and simultaneously the evolved atomic hydrogen penetrates the steel, causing decarburization and intergranular disintegration.

It was pointed out that from the corrective steps which have alleviated this trouble, it would appear that copper and oxygen were the principal agents involved in this type of metal damage.

In the consideration of high-temperature corrosion of superheater tubes, the general temperature conditions associated with high-temperature superheaters were discussed, and it was pointed out that usually deslaggers are used to keep the tubes free from ash or slag accumulations.

The high metal temperatures experienced with these superheaters are in the range where a reaction between iron and steam will occur, where air oxidation can be severe, and where the strength of ferritic-type alloy steel is relatively low. Because of the creep characteristics of steel at high temperatures, it was pointed out that stresses must be considered in discussing corrosion, since they are closely associated when failure occurs.

Some of the most severe cases of steam corrosion in superheaters that have been experienced by the authors were described, and they pointed out the following similar characteristics associated with these experiences:

1 The iron oxide produced by corrosion of both steam and flue gas adhered tightly to the unaffected metal.

2 The oxide was cracked both longitudinally and circumferentially and consisted of several layers.

3 The failures were stress failures brought about by weakening due to oxidation.

4 The tubes were subjected to considerable rapid cooling at intervals by steam or steam and water from deslagging operations.

By correlating the information obtained from the micrographic studies with that obtained from the general conditions associated with the failures, the chronology of events that led to the failures can be established as follows:

1 A thin tightly adherent oxide deposit forms on both the steam side and the gas side of the tube wall.

2 The temperature shock of the relatively low-temperature steam or steam and water from the deslaggers causes cracking of the oxide because of the different thermal-expansion characteristics of the oxide and the metal.

3 The surface exposed at the base of the cracks becomes oxidized.

4 This cycle is repeated many times.

5 The layer of oxide on the inside metal surface raises the metal temperature in the tube, thus increasing the oxidation rate.

6 Progressive oxidation from both the inside and outside of the tube wall reduces the thickness of the wall and increases the stress.

7 The increased temperature reduces the strength of the metal, which together with the increased stress (item 6) causes accelerated creep of the metal.

8 The accelerated creep continues until failure occurs.

It was stated that temperature shock is the main factor, but it was pointed out that it is possible to obtain satisfactory deslagging with mechanical equipment located and operated so that no damage to the tubes results, as evidenced by more than 100 high-pressure boilers installed by The Babcock and Wilcox Company with steam temperature between 900 and 950 F in which there has been no troublesome corrosion.

In addition, six separately fired superheaters installed during the war have operated more than three years with steam temperatures of 1300 to 1350 F at 25 to 30 psi without corrosion. Columbium-stabilized 18-8 stainless steel is used in the high-temperature portion of these superheaters.

The authors concluded that chromium-molybdenum steel alloys containing from 2 per cent to 9 per cent chromium, and 0.5 to 1 per cent molybdenum when properly selected for the expected temperatures, are highly satisfactory for use with metal temperatures up to 1200 F. Above this temperature it appears that the stabilized 18-8 stainless alloy is satisfactory, and indications are that this material will be more extensively used in the future with the higher steam temperatures.

Electronic Sealing

A NEW application of electronic sealing to transparent-box manufacture was announced recently by the Eastman Kodak Company, Rochester, N. Y., at the 1947 Annual Packaging Conference and Exposition in Philadelphia, Pa.

This new method is expected to speed up production, reduce waste, improve box appearance, lead to greater uniformity of product, and eliminate the distortion sometimes caused by the cementing operation usually employed in transparent-box manufacture. It is applicable to acetate sheet of a thickness of 0.005 in. and heavier.

No cement is used in sealing transparent boxes with this new method. The technique consists merely of firmly clamping overlapping portions of the box ends and sides between two electrodes. The "deep-heat" so produced fuses the two pieces of acetate in as little as 1.4 sec.

In spite of the high temperature developed within the acetate sheet, the outer surfaces remain cool and the electrodes never

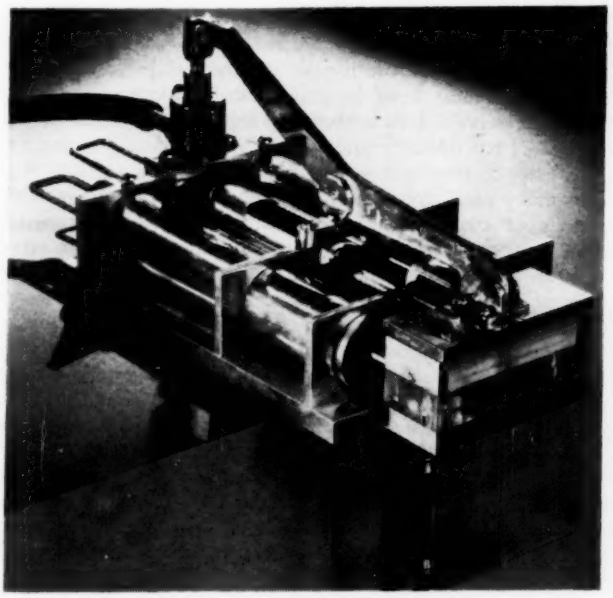


FIG. 4 GENERAL VIEW SHOWING SEALING HEAD AND TUNING STUB USED IN CONJUNCTION WITH A 200-MEGACYCLE, 150-WATT GENERATOR FOR EXPERIMENTAL WORK IN SEALING CELLULOSE ACETATE FOR TRANSPARENT-BOX MANUFACTURE

heat up. Box seams produced by this method are only 1/16 in. wide and almost invisible. Large "ears" are unnecessary on box blanks since the seams practically coincide with the corner crease.

Many of the standard high-frequency generators now on the market can be used to produce the power required for this purpose. Interchangeable electrodes or sealing heads to accommodate boxes of various sizes may be made in any machine shop.

Refrigeration Surgery

THE successful use of refrigeration not only as a shockless anesthetic when performing amputations but its extension to preservative and other uses, thus greatly widening its applications, is described by Dr. Lyman Weeks Crossman and Dr. Frederick M. Allen, City Hospital, New York, N. Y., in the *Journal* of the American Medical Association, Feb. 8, 1947.

Refrigeration anesthesia is becoming routine for many amputation cases. It is reported that mortality following amputation in severe cases has been spectacularly reduced by the "cold treatment."

The reason for the effectiveness of ice is that cold slows down all the processes of life. In any operation, the shock produced by the body's own poisons is one of the chief dangers. But when a part of the body is thoroughly chilled, it produces less of these toxic substances. Cold also inhibits the spread of bacteria through an infected wound.

A temperature of 40 F can produce anesthesia so complete that the patient feels nothing, not even when a nerve is cut or the bone is sawed. The nerves in the cooled, almost bloodless tissues cannot transmit painful impulses.

In the case of one actual amputation, no anesthetic was given—the numbing effect of the ice was enough. Throughout the operation the patient was in good spirits. Soon after it he ate a hearty lunch. There was no sign of nausea, and—most important of all—no shock.

It has been found that actual freezing, which is instantly fatal for the entire body, can be safely endured for brief periods by local parts, even by such delicate tissues as the liver and the brain.

As refrigeration is the regular commercial process for preserving dead meat from decomposition, so likewise it can be used to preserve a dead limb which for some reason cannot be amputated but which would set up a rapidly fatal poisoning if allowed to decompose.

In many cases preservation has been effective for variable periods of two weeks and upward. Inevitably, degeneration must occur in a bloodless limb and a modified demarcation must form. The final change in the dead tissues is more in the form of shrinkage and a mummification than the usual tissue mortification. Also pain and a modified intoxication may finally compel amputation. The usual reason for delay in operating is a bad general state of the patient; for example, most of the City Hospital patients have been those with severe cardiac disease transferred from the medical service because of a major embolism. Besides the chance of constitutional improvement, there is sometimes the advantage of a lower level of amputation. Obviously, the penetration of cold is more thorough in proportion as circulation is lacking, and efficient preservation even of the deep tissues is thus favored. No tourniquet is needed except briefly for anesthesia at the final amputation.

The first observations along the line of preservation of infected or injured parts were made when patients entered City Hospital with acutely dangerous infected gangrene, and legal permission for the necessary amputation could not be obtained immediately. It was learned that by use of refrigeration, not only could the operation be postponed safely for several days but even an improvement of the general condition resulted, thus lessening the operative risk.

A more definitive preservation may be attempted in treatment of other infections of the limbs, such as gas gangrene. Refrigeration is helpful even when amputation is inevitable, but in less extreme conditions the radical chilling contributes to save the limb in two ways: (1) By directly checking the toxin production and its deadening action on the tissues, and (2) by gaining time for administration of drugs or other systemic means of cure. A tourniquet is not employed except as a preliminary to amputation.

In cases of severe injury to a limb, refrigeration serves preeminently to gain time in an emergency by preserving the injured part for days or weeks until the patient gains sufficient constitutional strength to withstand amputation. A secondary benefit, however, is reported as the development of collateral circulation during the time thus gained, so as to permit a lower level of amputation. This may make the difference between an emergency amputation high in the thigh and an amputation just above the knee a few weeks later.

A still higher accomplishment is when refrigeration not merely tides over an emergency but prevents amputation altogether.

A woman who had severely burned her leg came to the City Hospital with her leg badly infected. Fearing that amputation would result in her death, her surgeon packed the leg in ice, planning to operate when her general condition was better. A few days later her condition had so markedly improved that the operation was delayed, and the refrigeration treatment continued. After eleven weeks of continuous treatment she was discharged; her life and her leg were saved.

In cases of mechanical wounds or burns where the tissue has been lacerated, macerated, or contaminated, refrigeration permits saving the whole of the living tissue which is partly sacrificed by the usual surgical removal.

An illustration in minor surgery was reported showing that refrigeration aids in restoring fingers which have been cut off so as to hang by a mere shred of skin. Such a finger may be kept well chilled according to instructions given by telephone and will thus remain viable at least during several hours which may elapse before the patient can reach the doctor. Theoretically the interval might extend to 24 hours or more, though there is no clinical proof of such a maximum. After the finger is sutured in place the reduced temperature is still continued for several days but is raised slightly day by day as the nutrition of the severed part improves.

The experimental restoration of entire limbs was demonstrated by surgeons who cut off dogs' legs, kept them in a refrigerator for twenty-four hours and then replaced them, with successful healing. Since animals' legs have survived after having been deprived of circulation by a tourniquet for fifty-four hours and tails similarly for ninety-six hours, the feasible limits of preservation of severed limbs may well exceed twenty-four hours. If a limb is fairly cleanly amputated, for example in a sawmill accident, there is a challenge to any near-by physician to pack such a part in ice and send it along with the patient to a hospital equipped for the necessary surgery. In this airplane age it is surprising that no attempts of this kind have yet been reported. A commoner type of case is the wounding of limbs in various ways which sever the main blood vessels but leave other connections with the body. Amputation is the established routine, but it is entirely practicable for such a patient to be transported long distances with the damaged part surrounded with ice bags, and considerable gaps in the blood vessels can be bridged by the recent methods of anastomosis. Nothing is risked or lost, and even if there is failure in a major-

ity of the cases a minority of successes will justify the attempt.

There is a variety of cooling machines for use in ice surgery. One machine has a boot and sleeve shaped to fit the leg or the arm. The machine is wheeled to the bedside and the attachment is wrapped around the patient's limb. A gage on the machine sets the temperature wherever the surgeon wants it. When the machine is turned on, a fluid chills the limb to the desired temperature and keeps it at that temperature until the time of the operation. Another development has been metal iceboxes and cabinets. These machines are electrically operated and are attached to the patient's bed. The arm or leg is placed in the cabinet and the temperature is lowered until the limb is thoroughly chilled. All these devices have been designed to cut down on nursing.

Parking Cars

ONE of the current traffic problems in nearly all large cities is that of parking cars. Unfortunately, the provision of parking areas or garages in the center of busy cities is generally impracticable since almost as much floor space is required for maneuvering as for actual storage, and this fact tends to make the charge for parking extremely high. A system which makes it possible to park more cars in a given area and at the same time provide for easy withdrawal of any one car, has been developed by Building, Engineering, and Mechanics Limited, 19 Cavendish-Square, London, England, W 1, and is described in *Engineering*, March 14, 1947. By this system the cars are parked side-by-side and bumper-to-bumper by machinery which consists essentially of a series of mechanically operated, moving platforms.

A diagrammatic plan is given in Fig. 5. Each of the 19 rectangles represents a moving platform of sufficient size to accommodate a medium-sized car. The platforms are fitted with wheels which run in parallel tracks of equal length and they are coupled together in the longitudinal direction. The vacant space between platforms 1 and 2 is required for transferring platforms from one line to the other. For this purpose a transfer mechanism is provided at each end of the unit, the couplings between the platforms being arranged to tie in the longitudinal direction only.

When an automobile is to be parked it is driven onto platform 11 and the brakes applied. The attendant then sets the unit in motion and platform 1 is transferred to the vacant space between platforms 1 and 2. The line of platforms *b* is then advanced mechanically until platform 19 occupies the space originally occupied by platform 1, thus making vacant the space originally occupied by platform 11. Platform 10 is then traversed across to this vacant space and, finally, the line of platforms *a* is moved until platform 9 occupies the space vacated by platform 10, thus leaving the unit ready to accept the next car.

The new process is entirely automatic, one complete cycle occupying 40 seconds and all the attendant has to do to withdraw a car is to press a switch corresponding to the number of its platform. The cycle is reversible and when delivering an automobile the mechanism selects automatically the shortest route.

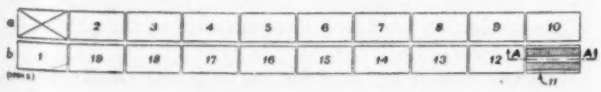


FIG. 5 DIAGRAMMATIC PLAN OF UNIT CAPABLE OF ACCOMMODATING 19 CARS

Reports From Germany

30,000-Ton Forging Press

A 30,000-ton German forging press, believed to be the world's largest, has opened up a new field in light-alloy forging according to report (PB-44675) now on sale by the Office of Technical Services, Department of Commerce, Washington 25, D. C. The report describes the I. G. Farben developments in the field of aluminum and magnesium production and fabrication.

The large capacity and die space of the press made it possible to forge shapes and sizes never before attempted. Engine mounting brackets about 10 ft long and aircraft wheels more than a yard in diameter were forged. About 75 per cent of the engine mounts and all the wheels were made of magnesium alloy. Only two operations were required to make an aircraft wheel—one to flatten the blank and another to forge the wheel. Complex magnesium forgings such as supercharger rotors were made and required a minimum of machine finishing. Experimental attempts to forge extremely long pieces had not succeeded up to the war's end. No work approaching the machine's theoretical capacity had been attempted.

The 30,000-ton press, put into operation in October, 1943, was twice the size of any die-forging press then in use. The design was limited by railroad-clearance dimensions and by a maximum practicable weight or 125 tons for any single piece.

The press approximates a double 15,000-ton press. Its total height is 80 ft, of which 27 ft is below floor level. The press has eight columns, 31 in. in diameter, and 8 cylinders, 41 in. in diameter with a 70-in. stroke. The ram and bed dimensions are 33 × 11 ft with a die opening (bed to ram, stroke up) of 9 ft. The die-shifting carriage has a 25-ft stroke.

Iron-Ore Washing Tower

A new washing-tower method of concentrating low-grade iron ore, developed in Germany, doubles the ore concentration and results in the recovery of more than 90 per cent of the iron content, according to Department of Commerce report (PB 44964).

The Wiedelmann washing tower, named after its German inventor, replaces the older method of dressing low-grade iron ore by screening, roll-crushing, washing in washing machines, and finally bucket-elevating the washed ore to cylindrical screens.

It is especially adapted for dressing low-grade ores containing clay or other material that can be readily suspended in water.

The tower consists of a large cylindrical concrete tank with a hopper bottom. An airlift pipe runs down the middle of the tower. The pipe extends above the tower to a near-by horizontal screen.

A charge of 0 to 50-mm ore is fed through an opening in the top of the tower. The charge is stirred by circulating air and water for 24 hours. The tower overflow carries off fine clay in suspension and the heavier iron-bearing ore sinks to the bottom. Compressed air enters the tower through the bottom and blows the washed ore upward into the airlift pipe where it is carried out to the horizontal screen for a second washing of 20 min. The screen is equipped with an agitating mechanism consisting of paddle arms attached to a rotating horizontal shaft.

Screen undersize (0 to 8 mm) and oversize (more than 8 mm) are collected separately, drained, and shipped to blast furnaces.

In a test run the Germans obtained a recovery of 91.6 per cent of the iron-ore content with an increase in iron-ore con-

centration from 21.6 per cent in the raw ore to 38.9 per cent in the washed product. It is claimed that ores washed by this process required the addition of less lime to the blast furnace than did ores washed by methods in which lime is largely removed. In some cases no additional lime was needed.

The Wiedelmann tower not only yields higher concentration and recovery of ore than the old method of grinding and washing, but is also cheaper to install and maintain as well as simpler to operate, according to German claims. Labor costs are said to be the same.

Refractory Materials

A clay-products kiln said to be of unusual design is described in a Department of Commerce report on the manufacture of German refractories and the use of refractories in the German iron and steel industry.

The novel kiln was in use at the Didier Works, Niederallendorf on the Rhine, producers of silica and fireclay refractories. In designing the kiln the firm sought to combine the efficiency of the ring kiln with the advantage of tunnel-kiln movement of ware. The kiln consists of a double row of chambers served by tracks and switching facilities. Each chamber will hold three cars containing 15 tons of ware.

A firebrick-lined framework attached to the end of the third car is so designed as to close the opening of a chamber when the cars are in place. The chamber then functions as a small closed kiln. The heated air from a chamber that has been fired provides preliminary heating of the next chamber to be used, thereby increasing the efficiency of firing. After firing, the cars of finished ware are shunted from the chamber to the loading platform.

The Mannesmann steelworks at Huckingen in the Ruhr reported what is believed to be the world's record for life of a basic open-hearth refractory roof. For 83 weeks beginning June 12, 1941, a 75-ton furnace was used continuously for 2923 heats, producing a total of 220,000 tons of steel. The roof, made of a chrome-magnesite material known as "Radex E," wore down uniformly and required virtually no repair during the period of use.

Turkish chrome ore, favored by the Germans for chrome-magnesite bricks, was used. The long life and satisfactory service of the furnace roof was due, in part, to the fact that uniform temperatures were maintained. No shutdowns occurred during the long period of operation. An interesting adjunct of the Mannesmann plant was the use of furnace slag to manufacture 6-in. cube pavement blocks in iron molds.

Multigraphed copies of the 113-page report, "The Manufacture of Refractories and Information Concerning Their Use in the Iron and Steel Industry of Western Germany," may be obtained from Mapleton House, 5415 Seventeenth Ave., Brooklyn, N. Y.

Supercharged Loop Scavenging

Use of a German "loop-scavenging" system of blowing out exhaust gases is claimed to greatly increase the output of an internal-combustion engine, according to Department of Commerce report (PB 40374).

Dr. Adolph Schnuerle, inventor of the system, claimed that tests had shown that a two-stroke two-cycle engine with loop scavenging could produce twice as much power per cylinder as a conventional four-cycle engine. To produce a given amount of power, therefore, loop-scavenging would permit use of half as many cylinders as would otherwise be required. In addition, an engine with the loop-scavenging system is simple in construction because it does not require valves.

The Schnuerle loop-scavenging system, which was widely used on German internal-combustion engines, has ports in the cylinder walls arranged in such positions and at such angles that the blast of scavenging air makes a reverse loop inside the cylinder, thus effectively cleaning out the burned gases.

The tests reported were made under the direction of Dr. Schnuerle during the period 1935 to 1943. Power per unit of fuel burned, according to the tests, compared favorably with the output from 4-cycle engines.

Silicon-Carbide

Silicon-carbide is a promising ceramic material for use in the high temperatures at which gas-turbine blades must operate, according to German tests outlined in Department of Commerce report (PB 47012).

Not only were test pieces of silicon-carbide strong and rigid far above 1300 C (nearly 2400 F) but they also showed exceedingly high-heat conductivity as compared with other materials tested.

The porous character of silicon-carbide bodies, however, is a drawback that will require additional development if they are to attain the strength required for use as turbine blades, according to a German engineer. Glazing increases the strength of silicon-carbide and protects the material against oxidizing gases.

Glazing silicon-carbide bodies, however, presents problems because heavy-metal glazes react with or infiltrate the base and leave the surface rough and porous. A method of getting around this difficulty is set forth in a statement of patent claims (in English and in German). An intermediate layer of stable materials, such as a mixture of calcined alumina and clay is applied under the glaze and both coats are fired together. The glazed silicon-carbide is said to be good for such equipment as gas-injection nozzles, gas pipes, heat exchangers, pyrometer pipes, electrical-heating elements, and crucibles, as well as for gas-turbine blades.

Motorcycle

A German motorcycle with sidecar, said to be extremely good for cross-country driving over rugged terrain, is described in a Department of Commerce report (PB 50400). The report gives the results of tests of the machine at the Aberdeen Proving Ground, Md.

The motorcycle with sidecar and spare wheel weighs 900 lb and carries a maximum load of 1000 lb. It has a wheel base of 4 ft 9 in., a ground clearance of 6 in., and a safe fording depth of 13 in. Its maximum speed is 75 mph. With very low oil consumption, the machine runs 35 miles on a gallon of gasoline.

A unique feature is that the sidecar wheel also drives. The drive from the transmission enters the rear gear case by means of a shaft mounted parallel to the direction of motion. The rear wheel of the cycle is driven by a ring and pinion gear, and from the right of the ring gear the drive passes through a differential to the sidecar wheel which drives in the same manner as a wheel on a standard vehicle.

The machine's transmission system is unusually sturdy and has eight forward speeds and one reverse, with high- and low-range selection operated by a lever mounted to the right of the gear-shift lever.

Hydraulic brakes are used for the rear and sidecar wheels; mechanical brakes for the front wheel. The machine carries a spare wheel and all wheels are conveniently interchangeable.

Jet-Engine Instruments

THE development of the gas turbine as motive power for aircraft has caused a corresponding change in instrumentation requirements. At the June, 1946, A.S.M.E. Aviation Meeting, Los Angeles, Calif., during a joint Aviation Division-Industrial Instruments and Regulators Division technical session, C. A. Edman, General Electric Company, West Lynn, Mass., described the changes in instrumentation which have thus far been suggested by the G-E I-16, I-40, TG-100, and TG-180 jet engines.

In general, the flight, navigational, and auxiliary instruments have not been affected by the introduction of the jet engine, but the number of essential engine measurements has been reduced to the engine speed, tail-pipe temperature, bearing temperature, oil pressure, and fuel pressure.

TACHOMETER

The need for a tachometer in the gas turbine, particularly in the propjet, is analogous to that of the reciprocating engine since the thrust of the engine varies with the rpm of the rotor.

An additional requirement is the existence of a definite minimum idling speed below which the engine will not perform satisfactorily.

The tachometer provided has been of the remote electrical type utilizing a generator with a two-pole permanent-magnet rotor. The generator is mounted on the accessories pad where it is driven by a special accessory shaft geared down from engine speed to a generator shaft speed of 4100 to 4400 rpm at rated rotor speed. Considerable discussion has centered about the methods of calibrating the indicator dial so as to designate the optimum operating range to the pilot clearly. One scheme proposed has been to calibrate the dial from 0 to 110 per cent with 4200 rpm being 100 per cent. A set of auxiliary gears would then be provided with each type of engine for converting the rated accessory-shaft speed to 4200 rpm plus or minus 25 rpm. This would require gearing in steps of 50 rpm. By this means the pilot would be relieved of remembering the rated speeds of each type of motor. An alternative scheme similar to that now in general use is to calibrate the tachometer indicator in engine rpm and add a warning mark in color at the critical or rated speed.

TAIL-PIPE TEMPERATURE INDICATOR

The answer to the tail-pipe temperature-measurement problem has thus far been found in a highly reliable line of thermocouple instruments, compensated for errors due to temperature changes in the windings and "cold" junction of the circuit. The primary detectors, in this case, open-type chromel-alumel thermocouples, have been mounted, six in parallel, about the inside diameter of the tail pipe. In some experimental installations this arrangement has varied, especially where a survey of the temperature gradient has been desired. In most installations, however, standardized mountings have already been specified.

As long as airplanes have been relatively small and the distance from the engine to the cockpit has been short, the thermocouple instruments have been highly satisfactory. With a growth in size of the jet airplane, however, it is becoming evident that the heavy leads and low-resistance joints associated with thermocouple instruments of low emf will cause a demand for other types in which the leads are much less bulky and joints less critical. Work has been done on resistance-bulb, ratio-type instruments for this application with good results, and it seems likely that bulbs will be available which will be able to withstand the high temperature and corrosive atmosphere of the tail pipe.

BEARING-TEMPERATURE GAGE

Until enough data are accumulated to insure safe bearing temperatures, both high and low, under all operating conditions, it will be necessary to maintain a means of indication of this temperature. Excellent results have been obtained thus far using thermocouple instruments, and in view of the nature of the problem, it seems likely that this type of instrument will continue to be used.

Ultimately, it is expected that bearing-temperature indication will be replaced by lubricating-oil temperature indication. Here again, as in the case of the tail-pipe temperature measurement, and for the same reasons, a resistance bulb will probably be used as a primary detector and a ratio-type instrument as the indicator.

OIL PRESSURE GAGE

The range of the oil pressure gage is dependent upon the type of bearings and lubrication system used. In the Type-I jet engines using ball bearings, a low pressure (about 10 psi) is permissible. Other engines utilizing sleeve bearings require higher pressures. In general, the problems involved are analogous to those on the reciprocating engine with the notable exception that the vibration is much less. One of the chief problems has been the effect of extremely high pressures when starting the engine in very low ambient temperatures. In spite of relief valves this has often resulted in the destruction of instruments. For this reason very high overpressure ratings are given the instruments.

FUEL PRESSURE GAGE

The fuel pressure on the gas turbine is a more critical quantity than that on the reciprocating engine. Because of the design of the fuel-injection system, the fuel nozzle actually acts as a metering device and, as such, is sensitive to changes in pressure. Were it not for the fact that the characteristics of the nozzle change rather rapidly because of the difficult conditions under which it operates, the fuel pressure gage might be calibrated in terms of flow. As yet this has not been found possible.

Ideally, the differential fuel pressure gage measures the pressure drop across the nozzle. Actually, since the line drop is low and since the pressure in the combustion chamber is about the same as that near the compressor outlet, the pressure drop is generally taken between the fuel-pump outlet, and the compressor discharge or the equivalent. The pressure ratings are very high as is characteristic of this type of engine.

FUEL FLOWMETER

An indication of the rate at which fuel is being supplied to the jet engine is highly important but not absolutely necessary for its operation. The purpose of such a measurement is: First, the rate at which fuel is being consumed supplies a quick check on the functioning of the engine; and second, the fuel consumption totalized over a period of time furnishes an accuracy check on the fuel-quantity gage.

On a jet engine, the fuel flowmeter, which is installed between the fuel pump and combustion chamber, must meter fuel which is under a pressure of up to 650 psi. Consequently, it has not been found possible to use the same units on jet engines as on reciprocating engines where pressures do not exceed 25 psi. Moreover, the rate of fuel flow tends to be higher on the jet engine necessitating further modifications in the construction of the gage. Add to this the fact that it has been found desirable to use mass flow rather than volume flow as a basic quantity and that installations must be of the remote-indicating type, it becomes apparent why the development of a completely satisfactory flowmeter has been rather retarded.

OTHER INSTRUMENTS

The only other engine instrument used at all extensively in connection with gas turbines for airplanes is the torquemeter. This is used on the propjet precisely as on the reciprocating engine to measure the torque being exerted on the propeller. Analogous to this measurement, however, is the measurement of the thrust of the jet engine in flight. As yet no satisfactory means for such a measurement has been devised.

Synchroscopes have not yet been found necessary because engine vibrations are small, and because the turbojets have been placed so close to the center line of the airplane that the yawing torque is negligible. The ultimate use of synchroscopes will depend upon the developments in the jet engines and in the means of synchronization.

The need for a lubricating-oil dilution gage, recording tachometer, engine-operating-time recorder, fuel-content gage calibrated in hours of flying time, and flight-data recorder, will also be felt in connection with jet airplanes.

New Train

MANY new features adding to passenger comfort are being incorporated in a new train which the General Motors Corporation announced recently as the "Train of Tomorrow."

The train is an experimental project aimed to try out new ideas for the improvement of railway travel.

A feature of the train—one that will add immeasurably to the scenic pleasures of traveling in sections known for their beauty—is the Astra Dome. This is the glass-enclosed observation roof on each car, a full-sized section capable of seating 24 persons in comfortable coach chairs or 18 in de luxe dining groups.

A special safety glass encloses the Astra Dome, so designed that it will filter out most of the sun's hot rays, and still provide clear and unimpeded vision on all sides and above. It is of double thickness, with a dehydrated space between panes to prevent frosting and insulate against both heat and cold. Air conditioning will provide ideal interior surroundings.

Other features include an observation lounge car in which almost complete glass enclosure is attained. Posts between extra-wide windows take up only a few inches and are so draped that a feeling of being completely surrounded by glass is attained. It contains, besides the Astra Dome, two cocktail lounges, one on a lower level, directly below the dome, and the third at the intermediate level in the front of the car.

Dining seating arrangement, besides that in the Astra Dome, is of the newest offset fashion, permitting easy access to all seats, without disturbing those already seated. The main section of the diner, at conventional level, seats 24 and there is room for 10 more in a lower, semiprivate dining room, located in the sunken portion of the car beneath the dome.

All of the cars of the train have four levels, the dome being one, and the conventional level a second, the ramped passageway beneath the dome at one side a third, and the lowest compartments, two steps down from the ramped passage, the fourth. This provides for a variety of movement and for room arrangements that will remove monotony of many long trips.

Sleeping accommodations on the train have been redesigned, with none of the old-style berths or sections. Persons traveling in groups can arrange for accommodations for as many as six together, by combining drawing rooms or compartments. All beds on the sleeper in the duplex roomettes for single occupancy, as well as the larger rooms, are constructed lengthwise of the train.

The day coach of the train is furnished as comfortably as the other cars, and has special baggage arrangements and baggage doors and lockers at one end, as well as a checking service for those who wish to go to the Astra Dome.

The train is completely air-conditioned and is provided with refrigeration facilities. Running ice water is found in all rooms of the sleeper and at convenient points in other cars of the train. The diner alone has enough refrigeration equipment to equal in cubic capacity what would be required in 15 average homes.

All of the electrical equipment is powered by a complete auxiliary Diesel-powered generating unit installed in each car and is wholly independent of the locomotive. This permits complete comfort when a car is detached or waiting in station or yards. The "electrical power package" for each car is said to be an innovation in railroad equipment.

The power unit for the train will be a 2000-hp General Motors Diesel passenger locomotive of postwar design.

Two outstanding features in the car trucks promote smooth riding: (1) Outside-hung swing hangers; and (2) roller-bearing journal boxes of advanced design, produced by the Hyatt Bearings Division of General Motors, which include an arrangement permitting lateral movement of the axles within the limits established by thrust blocks mounted on synthetic-rubber cushions.

The outstanding difference between standard truck design and that incorporated in the new train is the location of the swing hangers. On standard trucks, the hangers are located inside of the truck frame. In the new design the hangers are located outside of the frame.

It is claimed that outside hangers greatly add to the stability of the car by materially increasing the ability of the truck to dampen out shocks arising from imperfect track alignment, rough roadbed, sharp curves, and similar conditions.

The lower ends of the hangers are farther apart than at the top. This arrangement serves to stabilize the swinging parts by causing more resistance to free movement, and it permits a car to bank when rounding a curve. When a car is thrust off center by centrifugal force on a curve, the hanger on the inside of the curve swings in and slightly downward. At the same

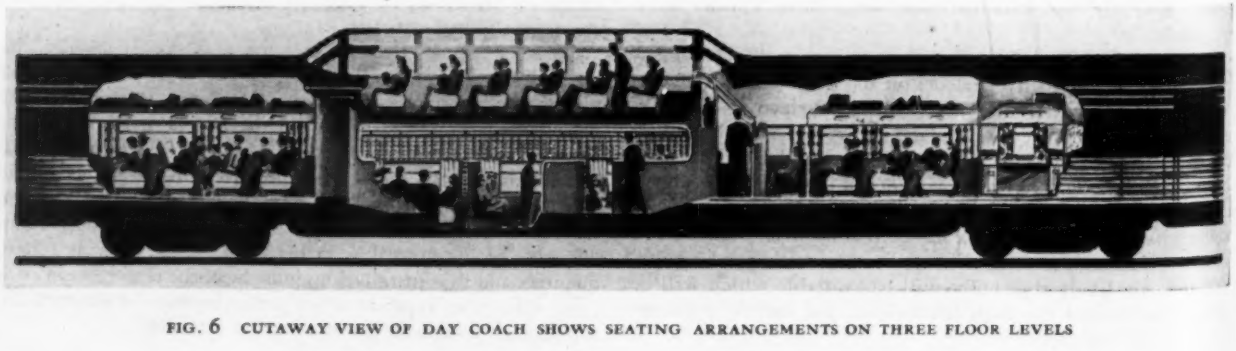


FIG. 6 CUTAWAY VIEW OF DAY COACH SHOWS SEATING ARRANGEMENTS ON THREE FLOOR LEVELS

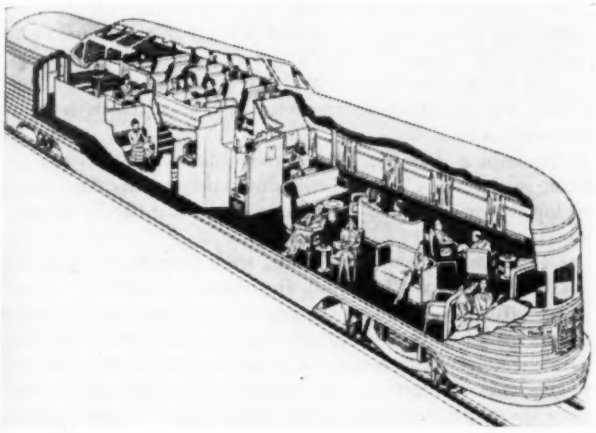


FIG. 7 CUTAWAY DRAWING OF OBSERVATION LOUNGE CAR SHOWS UNIQUE FOUR-LEVEL ARRANGEMENT, INCLUDING ASTRA DOME OBSERVATION ROOF

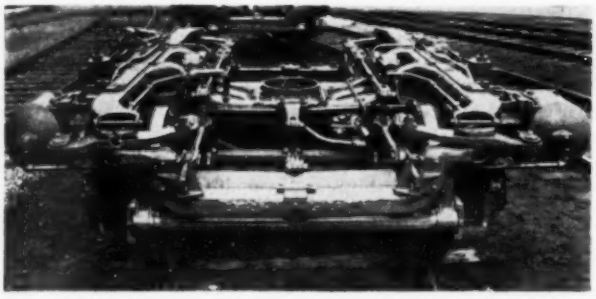


FIG. 8 END VIEW OF SPECIAL WHEEL TRUCKS FOR NEW TRAIN WHICH FEATURE OUTSIDE-HUNG SWING HANGERS TO PROVIDE SMOOTHER RIDING

time, the hanger on the opposite side, outside of the curve, swings out and slightly upward. Thus the car is held in a banked position as long as the centrifugal force is present. This built-in banking arrangement will accommodate itself automatically to both the degree of curve and the speed of the train.

The complete train will start a six-month schedule of public showings in principal cities sometime this month.

New Laboratory Location

A NEW site for the Argonne National Laboratory for research and development in atomic energy and acquisition of 3645 acres of land in Du Page County, Ill., were approved recently by the U. S. Atomic Energy Commission, according to *Science*, April 4, 1947. The site is approximately 26 miles southwest of the center of Chicago and 4 miles west of facilities of the laboratory in the Palos area of Cook County Forest Preserve.

Argonne National Laboratory was established for research and development in all phases of atomic energy, including fundamental research in physics, chemistry, biology, medicine, and engineering; the development of industrial power; and research on military uses.

Present facilities of the laboratory are housed in four buildings on the campus of the University of Chicago, the Museum of Science and Industry, and the Palos area of Cook County Forest Preserve. Operating difficulties due to wide dispersion of facilities were apparent early and a permanent site was sought. The board of governors of Argonne National Laboratory, of which Farrington Daniels is chairman, chose Chicago as the permanent site because of the geographical location and transportation advantages.

Prime consideration in the search for a permanent location was engineering features of the land. Topography, prevailing meteorological conditions, type of foundation, and available water, sewage, and power facilities were considered, and the Du Page County site was the only area investigated which satisfied all requirements. In addition, its proximity to the present Forest Preserve site will allow maximum use of facilities there during the transition period.

Construction plans call for some 12 major buildings to house administration; physics, chemistry, biology, medical, and engineering research; nuclear reactors and allied equipment. Construction will be spread over a period of approximately three years.

Argonne Laboratory, one of a projected series of national laboratories, is successor to the wartime metallurgical laboratory of the Manhattan Engineer District. Its facilities are operated by the University of Chicago under contract with the Atomic Energy Commission. The board of governors of the Laboratory, composed of seven representatives elected by the Council of Participating Institutions—Midwestern academic and research institutions—reviews matters of general policy and makes necessary recommendations for submission to the contractor and the government. A representative from each of the 25 participating institutions serves as a member of the Council.

Materials Handling

Palletization

THE development of the pallet or, more properly, the fork-truck-pallet combination, during and since the recent war, offers such great possibilities that it is engrossing the attention of everyone concerned with materials handling, according to an address which John D. Sheahan, secretary-treasurer, Drake, Startzman, Sheahan, Barclay, Inc., New York, N. Y., gave before the Production Conference of the American Management Association held in New York, April 24-25, 1947.

The U. S. Army, which gave palletization its big boost, bought more than 6000 fork-lift trucks and about 6,000,000 pallets, and found that there was practically no commodity in its depots that could not be palletized in storage. The majority of them could also be shipped on pallets. The Army estimated that its mechanical-handling techniques took the place of 25,000 laborers who simply were not available. In one year, on labor alone, the equipment saved more than it cost. The great savings, however, were not confined to labor. Through improved utilization of storage space by palletization, it was possible to store 30 per cent more supplies in the existing space. This saved the construction of 40,000,000 sq ft of additional warehouse space. The Army figures cost of construction at $5 per sq ft, therefore saving $200,000,000—approximately five times the cost of the equipment.

The great virtue of palletization is that it permits multiple small units to be combined and handled as one large unit. Each time a motion in handling products is eliminated, costs are reduced. The ideal materials-handling system is one which consists of the fewest possible motions and makes each required motion accomplish the largest possible unit of work.

Take, for example, the moving of 1000 cartons 200 ft and

warehousing them. Assume that the task is to be done by hand, carton by carton. A laborer can pile 200 cartons per hour, and he can carry them 200 ft per min. It will require 5 hr to pile the cartons and 33.3 hr will be consumed in transporting them to the pile and returning to the original location to pick up another pile, or a total of 38.3 man-hours. If, on the other hand, the laborer operates a hand truck and can carry 5 cartons, his travel time is only $^1/_5$ as much, or 6.6 hr, but in this case he has to pile twice, once on his truck and once at destination, so piling requires 10 hr, making a total of 16.6 man-hours. If given a four-wheel flat-bed warehouse truck on which he can carry 20 cartons, the travel time is reduced to $^1/_{20}$ of the original, or 1.66 hr, while the piling time remains at 10 hr, or a total of 11.66 man-hours.

Generally speaking, the larger the unit, within the limits of the facilities available, the greater the savings. It is only when travel time is less than piling time that the carton by carton method is most efficient. When travel and piling time are equal, the method is optional.

If the current wages of $1 per hr are applied to the problem, it can be found that the first method costs $33.30, the second $16.60, and the third $11.60. It will be noted that the man carrying one package at a time is more efficient in one respect—he piles only once and expends only $^1/_2$ the time that the operation requires if he is using either of the two types of trucks referred to.

By using the fork-truck and pallet method this difficulty can be overcome and the piling operation made as efficient as the manual handling and the transportation operation made more efficient than any of the other methods. The pile is made at the source by loading a pallet and moving a whole section of the pile successively to a new location, eliminating the necessity for double handling of the individual packages. In this case, one piling operation involves 5 hr piling on pallets. The pallet will ordinarily handle more than twice as many pieces per trip as the four-wheel truck and the machine will travel approximately twice as fast. Therefore piling time is reduced to the original 5 hr and travel time is reduced to $^1/_2$ hr or $5^1/_2$ hr for the entire operation. Thus handling costs have been reduced by more than 70 per cent after allowing for higher wages and equipment costs.

Electric Industrial Trucks

Some new developments in electric industrial trucks were described by B. I. Ulinski, chief engineer, truck division, Automatic Transportation Company, Chicago, Ill., at the Pittsburgh Mechanical Engineering Conference held in Pittsburgh, Pa., April 22, 1947. The conference was sponsored jointly by The American Society of Mechanical Engineers, Engineering Society of Western Pennsylvania, Society for the Advancement of Management, and the Material Handling Society.

As representative of current trends in electric trucks, Mr. Ulinski described the Sky Lift. Its forks raise to 130 in. and it collapses to the standard height of 83 in., the necessary height for a truck to pass through the customary factory door. At the same time, it is said to be the only hydraulically operated fork truck which will stack to ceiling heights in low-clearance buildings or boxcars. Its telescopic upright and its forks raise independently, which means that the upright does not begin to extend until the forks and their load have reached the top of the lowered upright. In previous-model trucks, the upright began to extend as soon as the forks left the ground level, thus raising the upright to the ceiling long before the load itself reached that height.

This truck operates almost like an automobile—the steering wheel, foot brake, and accelerator are all in their customary positions and operate exactly as on an automobile. In addition, the tilt and lift are controlled by a single lever, similar in position and operation to the steering-post gearshift lever on newer-model cars.

It is claimed that the truck has the first high-pressure hydraulic system to be adapted to industrial-truck use, and it was developed from the high-pressure systems used chiefly on wartime aircraft.

Its electrical system is regulated by a pneumatic controller which operates exactly as an automatic gearshift on a car. The operator merely selects any one of four speeds by depressing the foot pedal to the correct position and the controller then starts the truck in low speed and automatically accelerates to the faster speed selected. This controller prevents jerky starting or reversing, reduces wear on tires and on the truck itself, and reduces the peak load on the electrical system by two thirds.

SPECIAL ATTACHMENTS

In addition to new developments in basic truck design, most electric-truck manufacturers are devoting more and more attention to developing special attachments—either to replace or complement the conventional forks or platforms—to enable their trucks to perform specialized jobs. These attachments are usually designed to be installed on trucks of any size or type, depending upon the job to be done.

An interesting example is a motorized boom attachment for use in railroad service shops and roundhouses. This boom replaces the regular forks and thus can be raised to the full height of the truck's uprights. It is mounted on a pivot and can be swung up and down, thus further increasing the maximum height to which it will reach. It can be rotated sideways as much as 60 deg in either direction. These features will enable a truck equipped with the boom to operate as a crane truck. It can be used to handle compressors and driving rods on the side of a locomotive, remove generators and other equipment on top of locomotives as high as 18 ft, and reach in from the front of the locomotive and remove the superheater tubes.

Of special interest is a clamp attachment for handling loose metal plate. This clamp is attached to an arm pivoted at the top of the heels of the fork. This truck's regular lift chain is attached to the rear of the pivoted arm instead of the forks themselves. A spring keeps the clamp open when the forks are empty. The weight of a load, however, closes the clamp, thus preventing loose tin plate and similar loads from slipping off the forks.

Other special attachments for handling special types of load include various roll-over devices for picking up, rotating, and depositing rolls of paper or similar commodities; and several types of drop buckets for handling and depositing scrap and other loose materials.

One of the newest and perhaps most significant developments in the line of special handling devices are those designed to handle loads without pallets or skid platforms or using cardboard, fiberboard, or similar expendable materials as a platform.

An example is a clamp truck featuring hydraulically operated padded clamps which grasp loads too light or bulky to remain stable on a pallet.

Another design in progress is for a clamp attachment which will automatically pull an unpalletized load onto the forks and push it off the forks in a storage area or boxcar. It can also be used with what is called an "X pallet," a corrugated metal structure which enables a truck operator to pick up the load by itself or on the pallet by placing the truck's forks either below or above the pallet corrugations. The combination of this

pallet with the push-pull clamp attachment will be especially valuable in plants which use palletized handling but which receive incoming goods unpalletized.

SPARKPROOF AND EXPLOSION-PROOF TRUCKS

Equally important is the development of sparkproof and explosion-proof trucks.

Safety has always been a feature of electric trucks. They exhale no volatile fumes, exude no incendiary exhaust, and require no explosive fuel for their operation. The last few years, however, were devoted to the development of electric trucks which would be perfectly safe even in hazardous operations. One of these is the sparkproof truck, which has all electrical equipment enclosed so as to retain the sparks within metal casings and thus prevent any possible ignition of combustibles in the atmosphere. Such trucks have been used, for example, in grain elevators and mills where the extremely dusty atmosphere makes any other type of truck unsafe.

The second type of truck is the explosion-proof truck—an even more highly developed refinement of the same principle. Designed primarily for operations in munitions plants during the war, this truck has all electric contacts enclosed in fitted steel casings which perform two functions: First, they retain sparks and prevent direct ignition of the atmosphere; and second, casings are built with sufficient strength to retain explosions internally if inflammable gases creep into the electrical contact areas, thus preventing ignition of the great mass of gases in the atmosphere.

Greater Productivity

INDUSTRY'S need for more productivity from the better use of tools and equipment seems to become more urgent with the passing years. Greater productivity is the only means industry has today of obtaining a more favorable ratio of profit volume, thereby guaranteeing a profitable return on investment. To accomplish this purpose, industry must take advantage of all possible cost reductions without jeopardizing production volume.

In an article in the March, 1947, issue of *Advanced Management*, L. J. Bayer, chief, methods and standards, Warner and Swasey Company, attempts to show that the task of increasing productivity through the better utilization of tools and facilities must be undertaken on a broad plant-wide basis, if substantial gains are to be made. The purpose of the task should be the welding together of six major divisions, namely, engineering, methods and standards, tool design and control, production control, manufacturing, and inspection, into a well co-ordinated unit. Each division has obligations and responsibilities which when properly defined and administered, will result in the highest possible productivity.

Engineering, as the initial division affecting all plant functions, must have a designing and drawing policy established upon practical and well-defined standards. The knowledge of the product should be clearly and fully conveyed through the medium of shop drawings.

The methods and standards division has a twofold function: To devise and develop means by which the manufacturing division can meet engineering requirements effectively; and to determine and set up fair time ratings on all manufacturing operations to assure the control of manufacturing costs.

Tool design and control being functions closely allied to methods and standards must therefore also be closely coordinated with this division. They should be guided by the methods and standards division in forming their pattern of activity in order that tool costs are kept at a minimum yet serving the need in the shop.

The production-control division should be able to meet the demands of the sales division within the predetermined expectancy of management based on work load ahead and machine capacity in the shop. The emphasis should be on a well-constructed system of machine-load balance, which in accordance with general accepted practices is an order-entry and follow-up system that allows the shop to devote the maximum amount of time to the job of making quality parts at a reasonable cost.

The manufacturing division should be responsible for quality production at reasonable cost. It involves proper equipment, suitable jigs and fixtures, well-conditioned cutting tools of needed types in sufficient numbers, a well-directed job and tool service group, and a convenient arrangement of shop equipment and supplies. Above all, shop supervision must have enough available time and assistance to respectively supervise, guide, and teach both skilled and new unskilled employees.

Inspection should have the assignment of maintaining and only maintaining a level of quality established by the engineering division and conveyed by the shop drawings.

Passenger-Car Weight Reduction

THE problem of reducing the weight of passenger-car equipment and specialties was discussed by P. W. Kiefer, fellow A.S.M.E., chief engineer, Motive Power and Rolling Stock, N. Y. Central System, New York, N. Y., at a Railroad Division technical session during the 1946 Annual Meeting of the A.S.M.E.

In order to size up the present situation a condensed comparison of the coach of the late 1920's with a representative streamlined coach of today is made by Mr. Kiefer. The basic statistics are given in Table 1.

TABLE 1 COMPARISON OF PASSENGER CARS AND EQUIPMENT

No.	1	2 Coaches	3 Coaches	4
		Late 1920's non-AC, carbon-steel riveted body	1945. AC high-tensile low-alloy steel welded, nonfluted body	Per cent change col. (3) compared with col. (2)
1	Complete car, lb	130,900	121,000	— 7.5
2	Two four-wheel trucks, complete, ready for service, 36 in. multiple-wear rolled steel wheels, lb	34,000	39,500	+16.1
3	Body, completely equipped, lb	96,900	81,500	—15.9
4	Equipment and specialties, added to the body shell, lb.	40,300	50,600	+25.5
5	Body shell, without equipment or specialties, lb (Item 3 minus Item 4)	56,600	30,900	—45.4
6	Body equipment and specialties, percentage of complete body. (Item 4 divided by Item 3)	41.6	62.0	+49.0
7	Coupled length, ft	79	85	+ 7.6
8	Passenger seating capacity	84	56	—33.3

From Item 7 of Table 1 it is seen that the coach of 1945 (column 3) is 6 ft longer than the coach of the 1920's (column 2). This modern coach contains tightlock couplers and swinging supports, a complement of heavy metallic connectors, air-conditioning (AC) and modern ventilating apparatus with cor-

respondingly heavier generating equipment, much larger batteries, a number of electric control devices, streamlining including end closures and folding steps, more extensive lighting, high-speed brakes, roller bearings, and otherwise specially equipped trucks, and numerous other features, but regardless of these additions and increased length, it is about $7\frac{1}{2}$ per cent lighter than the coach of some two decades ago. This is the result of better materials and processes, accumulated experience, and careful designing throughout, including the development and installation of the large amount of additional specialty equipment for the comfort, convenience, and safety of the occupants, not embodied in the older car. It might be said that the older coach (column 2) has a seating capacity of 84 against only 56 for the modern unit, but the seats of the latter are of the de luxe revolving reclining type and the combined lavatory and smoking rooms are much more spacious and better equipped.

Item 5 shows that the body-shell weight of the modern car (column 3), without equipment or specialties, has been reduced about 45 per cent as compared with that of the older coach (column 2) although the length has been increased $7\frac{1}{2}$ per cent, and the inside clear width is about 4 in. greater than that of the older car. This reduction has resulted from the availability and adaptability of improved high-tensile materials to body-construction purposes, in combination with careful research, design studies, and better methods of fabrication and construction.

Certain features added to the car body are frequently provided by the builder, such as tightlock coupler supports, vestibule trap doors and steps, supply tanks, supporting structures inside and outside of the car, doors, interior partitions, built-in seats and similar furniture, and a large amount of miscellaneous hardware, in which, taken collectively, some worth-while further weight saving should be made independently of the weight of the body shell without detrimental effect.

One of the difficulties faced in the analysis of this question is the lack of detailed weight information comprehensively broken down for the other parts of the car, including running gear. The trucks complete, ready for service, should serve as a good example. By using an approved and established alloy steel for the important castings consisting of frames, bolsters, center plates, spring planks, equalizer spring seats, filler blocks, and miscellaneous items, it has been demonstrated that about 1550 lb per car set can be saved as compared with these parts made in "grade-A" cast steel and other presently used materials as were embodied in the trucks of the modern car (column 3). While this represents a worth-while reduction and amounts to about 1.28 per cent of total dry-car weight, it leaves for further consideration, exclusive of wheels and axles, such items as clasp-brake rigging, brake cylinders, shoes and keys, slack adjusters, piping and fittings, equalizers, swing hangers and connections, shock absorbers and supports, roller bearings and boxes, wheel slip-control mechanisms, and a number of other miscellaneous parts, all of which amount in weight to some 14,000 lb or about 11.5 per cent of the total dry weight of the car.

Item 6 of Table 1 shows that body equipment and specialties represent approximately 62 per cent of the weight of the fully equipped and complete body. This includes coupler equipment, windows and fixtures, inside finish and furnishings, heating installations, water supply, body foundation and pneumatic-brake parts, electrical equipment, insulation, and air-conditioning and ventilating apparatus.

Each of the items making up these respective classifications should be studied in detail and one of the essential needs is a careful breakdown of the weights of the respective component parts, including for each detail, separation of construction materials necessary for installation.

Other possibilities of weight reduction, which in total might come to a substantial figure, may lie in the direction of developments now under study and experiment, such as the following: High-speed compressor for air conditioning directly connected to a specially designed driving motor; a new-type battery, such as nickel cadmium, having different internal-resistance characteristics and lower ampere-hour capacity than that of the conventional lead battery now used; an inductor-alternator type of generator, without commutator brushes, or collector rings, designed to produce three-phase alternating current for conversion by means of a rectifier to direct current at the desired voltage, if it is found feasible to produce such a generator for an output of 20 kw or higher.

Mr. Kiefer stated that some responsible and recognized authorities contend that certain specific additional costs per pound of weight saved can be justified and paid for in new cars. However, economic developments indicate that a new appraisal of the situation is necessary and that the passenger-service accounts require in some manner or other, that over-all costs of operation be reduced and not increased.

Some part of this vitally needed economy should be derived from further passenger-car weight reduction. Shortened schedules are rapidly being introduced, and as "speed means power," the value of having saved about 175 to 200 tons in the present modern representative passenger trains consisting of, say, 15 cars each, as compared with equivalent trains made up of the designs of the 1920's, is not difficult to visualize. It is hoped that in due time there will result a substantial widening of this weight-difference spread with corresponding benefits in the advancement of passenger-service art.

Machine-Tool Forum

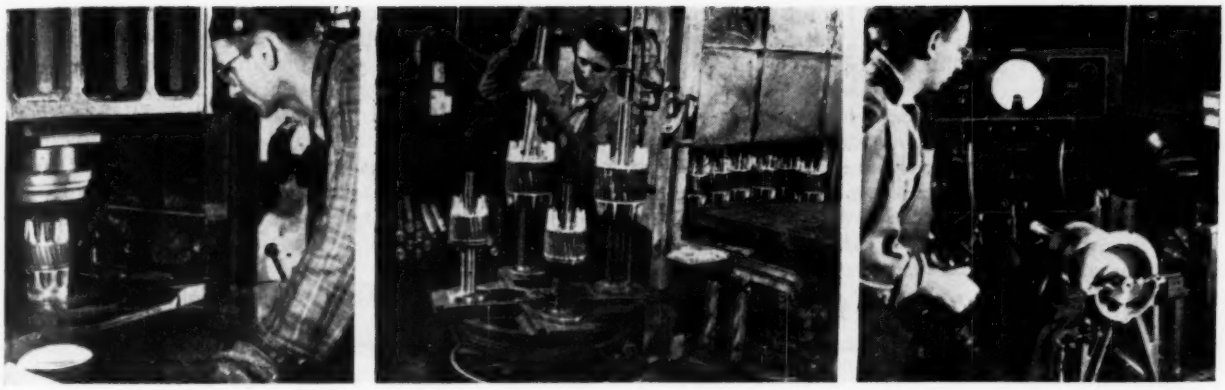
MORE than ninety company members of the National Machine Tool Builders Association responded to an invitation by the Westinghouse Electric Corporation to attend a Forum on the electrification of machine tools, held at the new Buffalo plant, April 21–24, 1947. This was the eleventh forum to be held in the last twelve years, as the meeting scheduled for 1945 was canceled because of stringent travel conditions. Approximately 300 representatives of the various firms attended.

The Westinghouse Buffalo Division is housed in the former Curtis Wright Plant, at Cheektowaga, N. Y., having a total floor space of 2,238,000 sq ft and another 100,000 sq ft will be added.

The meeting was highly significant as it was only one year ago that the corporation moved their Motor Division into a bare plant. During the year, in spite of the handicaps of shifting machinery and training an entirely new personnel, production, instead of falling off, increased from 20,000 to 29,000 units during the move. In addition to the production of motors, a portion of the plant will be devoted to the manufacture of electrical controls.

Subjects selected for discussion by the National Tool Manufacturers Association were covered by papers presented at the various meetings. The nature of these papers gave a broad coverage of the problems now being faced by industry. Discussions following each paper emphasized the necessity for improved machines and controls by which production can be increased and costs reduced in order to combat increasing production costs.

L. W. Ludwig, manager of Westinghouse Buffalo Divisions, stated that whereas a profit had been made in 1945 on a $20,000,000 volume of business, it had been necessary to increase this volume to $45,000,000 for 1946 to break even, and that an



(a) (b) (c)

FIG. 9 ROTOR ASSEMBLY

[(a) Assembled laminations are placed over the die well of a hydraulic press and molten aluminum, under a pressure of 100 tons, is forced into the die, filling the core slots, and forming the blower blades and balance lugs. (b) Rotors are expanded in a continuous oven and the shaft inserted. Shrink-fit eliminates use of a key and gives strength in torque well in excess of that needed. (c) Aluminum blower is shrunk on shaft and the entire assembly is diametrically balanced.]

estimated $50,000,000 would be required for 1947. It is hoped to attain a volume of business of $72,000,000 per year.

The new Life-Line Motor, announced at the 1946 Forum, has now been in production for just one year and has proved highly satisfactory. The use of rolled and pressed plate to replace cast frames has resulted in a reduction in weight which amounts to approximately 50 pounds in a one-horsepower motor.

Additional space provided by the new plant will make it possible for Westinghouse to roll the frames for these motors in their own plant. This will provide a closer control over production and make available for production purposes much of the floor space now used for storage.

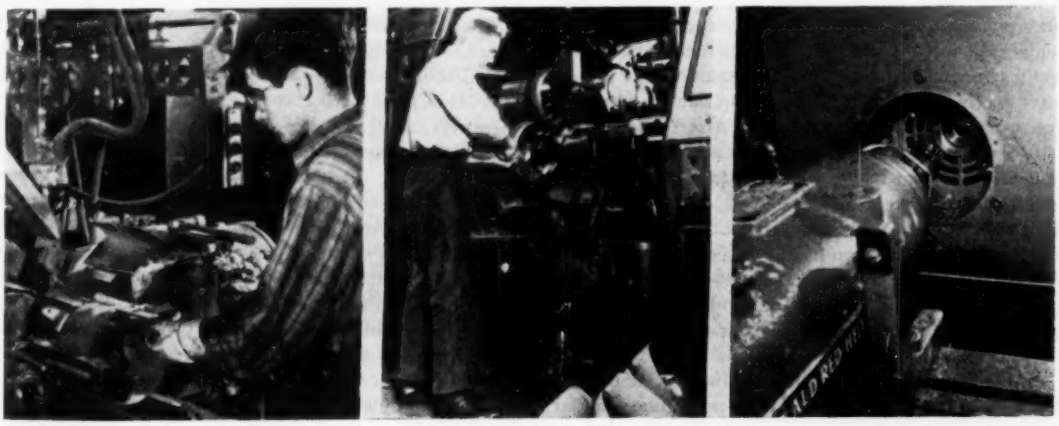
A simultaneous development of a new motor and a new plant has introduced a great number of mechanical difficulties that have been overcome by careful planning and the study of required equipment. Production-line methods are used throughout from the slitting of sheets for core stampings to the crating and shipping of the finished motor.

Scrap material drops to conveyer belts under the floor and is carried to a baling machine where it is compressed into blocks. The pressure used for baling is sufficient to form a solid block without the necessity of further binding.

Special equipment has been developed by Westinghouse and jigs used for automatically welding the rolled shells into perfect circles and for attaching the pressed steel feet to the shell. The formation of the end plates of the shell has been simplified by forming the plates and hubs separately and joining them by automatic welding in a jig that accurately centers the hub. Submerged welding is used throughout.

Accuracy of alignment is obtained by careful design and a system of progressive machining. The rolled and welded shells are machined on both ends simultaneously on jigs that center them by their inside diameters. The shells are turned to correct length and a rabbet joint formed on each end.

The end plates are loaded one at a time on a six-spindle Gridley automatic-checking lathe and centered by their outer surface. The ends are finish-turned to a rabbet joint and the hub is rough and semifinish-turned for the bearing and shaft bores. The finish cut in the hub is taken on a lathe in which



(a) (b) (c)

FIG. 10 SHELL AND END-PLATE PRODUCTION

[(a) Rolled shell is clamped on mandrel and the seam welded by submerged arc process on automatic machine. (b) Rabbet fit is finish-turned to 0.002 in. tolerance and hub is rough and semifinish-turned on six-spindle automatic chucking lathe. (c) Bearing fit is bored to a ±0.00035-in. tolerance; tungsten tools used exclusively.]

the end plate is centered by the rabbet joint in a special jig to insure proper alignment.

The construction of the core is of special interest from a mechanical standpoint as the keyway has been eliminated without weakening the rotor in torque. The stamped laminations are piled to the required thickness and held between end plates by four holding rods. A reamer passed through the shaft hole insures proper size but does not entirely remove the roughness of the stamping. The core is expanded in a continuous furnace and then shrunk onto the shaft. The assembly will withstand a tremendous torque far in excess of the motor requirement.

Throughout the construction of this motor, it is noticeable that the design calls for only the required degree of accuracy without extra effort being spent on a high degree of finish when such finish does not contribute to the performance of the motor.

Figs. 9 and 10 show a few of the processing operations being performed on the motor parts.

In addition to the construction of motors and control units, Westinghouse has installed a wire-drawing plant. Wire is drawn from 0.042 to 0.010 in. through a series of 16 dies. The drawn wire is passed through a bath of liquid insulation and is then baked. Some specifications call for special insulation for tropical use and this can be furnished when necessary. It has been found, however, that the standard insulation will meet most requirements even under tropical conditions.

The transfer of the motor and control divisions to Buffalo has been made at an outlay of $36,000,000, over $4,000,000 of which has gone into new tools. At the present time, approximately 3500 workers have been trained and this number is to be increased to 7000 as the division develops. More than 50 per cent of these employees are veterans.

Cobalt

EMERGENCE of the gas turbine as a source of power gives a new and increased importance to cobalt and emphasizes the precariousness of our position of dependence on imports of the metal, according to the March, 1947, issue of *Science and Appliance*. The alloy most commonly used to stand the heat of the gases impinging on the buckets of gas-turbine rotors is vitallium, a combination about 65 per cent cobalt, 30 per cent chromium, and 5 per cent molybdenum. Vitallium, first acclaimed for its use in dentistry and bone surgery, got extensive employment during the war in turbosuperchargers for airplanes. Application to turbines for jet engines was a logical development. At the rate we were increasing our use of cobalt for this purpose, according to the *Bureau of Mines Yearbook*, by the end of 1945 we should have been using about 600 tons of cobalt per month if the war had not ended when it did.

A new refining process, recently announced, will facilitate the production of cobalt from our relatively scarce and lean domestic ores. Just as an indication of our dependence on foreign supplies, our 1945 imports (on a metal basis) were nearly $3^2/_3$ million pounds from the Belgian Congo, about 300,000 pounds from Canada, and 450,000 pounds each from Belgium and Germany.

Cobalt costs about $1.60 per pound in industry. It is being prospected for in the United States, Canada, and China. So far, Africa is much the richest continent in cobalt. The Belgian Congo is the largest producer, with between 3 and 4 million tons of metal. Northern Rhodesia is next in world production, although the figures are not made public, and French Morocco is also high.

At home we have small scattered operations in cobalt, with Missouri first in domestic production and Pennsylvania next.

Our 1945 use of cobalt was about $5^1/_2$ million pounds of the metal. It was used as metal and alloy, and for such chemical purposes as enamel frits, paint driers, and pigments—around 100,000 pounds of metal for that purpose. High-speed steel required about $^1/_3$ of a million pounds of cobalt. The largest use, about $1^2/_3$ million pounds, was for materials such as stellite and carbide alloys to stand extra hard service. Next came magnet cores, with more than a million pounds of cobalt.

Industrial Design

THE annual meeting of the American Designers Institute held at the Metropolitan Museum of Art, New York, N. Y., on April 25, 1947, revealed some interesting facts and material concerning industrial design.

In one address, Royal Bailey Farnum, chairman of the National Conference of Schools of Design, said that the welfare of the world must in a large part depend upon both national and international trade, which in turn must rely upon product design in all its phases if success and therefore peace is to be achieved.

He then presented a review of the art and industry over the last quarter century in which it was pointed out that during the last 25 years design and utility have constantly shifted from a businessman's fear of design contamination to a frantic demand for the designer's services. With this industrial-design movement there had been a lot of agitation both here and abroad for many years before the industrialist was awakened to its possible value.

As early as the middle of the 18th century some manufacturers in the Commonwealth of Massachusetts expressed the idea that at least a course in drawing and design in the public schools would provide better craftsmen in the industries. It was the period when it began to dawn on some people that while the machine was tending to supplant human labor and skill of hand, at the same time it was producing some terrible looking products.

Massachusetts passed an act making drawing a required school subject and later in 1873 the state established an advanced institution, beyond high school, to train teachers for this new course of study. This was the first and wholly state-supported art school in the country, set up primarily to benefit design in Massachusetts products of industry.

Then the American Centennial Exposition in Philadelphia, Pa., brought the question of design and utility into sharp focus and demonstrated the need for greater application of design if this country was to compete with the products from abroad. However, design in those days meant primarily period style and superficially coated historic ornament. Two leading schools today are the direct result of the Exposition exposé: Rhode Island School of Design and the Philadelphia Museum School of Industrial Art.

At this early date decorative design was the sole art consideration of manufacture, and historic styles and ornament appeared both in advertising and on the product. Functional design as a problem of the artist was unheard of. Slowly but surely, however, the industrial-design movement was continuing. Foreign competition, expositions, art education in public schools, and inartistic American forms of utility were fomenting unrest. It might be argued that advertising tools took the lead in projecting the newer ideas. Certainly a few merchants and manufacturers took noble chances and created new forms. Then advertising artists glorified them. The background was prepared for a new scene.

In 1919 the Rochester Chamber of Commerce was invited to

co-operate with the St. Louis Art League "to assist in the promotion of the movement to awaken American manufacturers and businessmen in general to the necessity of providing original designs in industry for the coming competition in domestic and foreign trade."

In 1922 two large merchandising firms, the Woolworth Company and S. S. Kresge, were asked if there had been any noticeable improved taste in the American public to the extent of demanding simpler and less ornate objects of beauty and utility. Vase forms were stressed.

The Woolworth Company replied that the trend of the thinking public is toward more artistic shapes and simpler designs with subdued and less ornate styles of decoration.

The Kresge Company replied that the public is being educated to plainer designs and does not care for old-style fancy vases and glassware that formerly had been widely sold.

Both companies further stated that the only class of people that called for the gaudy highly decorated ware were the foreign group in large manufacturing and mining districts.

With increasing momentum, trade journals, house organs, and magazines published addresses and articles on industrial design.

The 25-year period may well start with the study entitled "Art in Industry," made in the field of industrial design by the late Charles R. Richards. This study devoted most of its pages to an analysis of the trades and industries principally in and around New York City. It was designed to ascertain the conditions pertaining to American industrial art, methods, and operations.

Since then the recognition of art and design has been rapid.

By 1929 national magazines were stressing the attractiveness of products by using, in bold type, such words as style, design, color, taste, texture, and beauty, even coupling the word beauty with efficiency.

One could now present a growing, almost inexhaustible series of publications dealing with industrial design and allied subjects, because new alloys, synthetic materials, and new processes not only become material for manufacture, but require the most comprehensive approach of the artist and designer, the originator of new forms with new tools and materials.

NEW METHOD OF PROPORTIONS

M. Le Corbusier, internationally known architect, designer, and town planner, at the same meeting, introduced for the first time his new method of proportions, the "modulor."

According to Le Corbusier, a new problem presenting itself to technicians in the building field is that of determining the dimensions which are to be given to the great mass of prefabricable objects; to the objects themselves, and to the objects that are to contain them.

The phrase—"Out of uniformity, one day boredom was born"—expresses a threat that up to the present seems to challenge mass production. From the truths inherent in the dimensions of the human figure—in which the golden mean is expressed—a scale, promising limitless series of proportions, can be obtained, which brings to visual perception what the Pythagorean scale of the sixth century B.C., the Zarlino scale of the sixteenth century, and the tempered scale of Bach, eighteenth century, brought to auditory perception.

For several centuries on the disposition of the sole seven notes of the tempered scale, which mark the most advantageous moments of the human auditory system, Bach, like Beethoven, Berlioz, Franck, Debussy, and Stravinsky, was able to reach the very depths of auditory preception. In a parallel sense, it may be justly said, in so far as mass-produced objects are concerned, that a scale pertaining to the visual perceptions will someday be used to the profit of the whole world, thus happily bringing to an end the approximations and the uncertainties, the heterogeneity and the inconsistency of present systems of measure, which are continuous points on a line and which by their very nature cannot crystallize into any form.

Such a scale is the modulor. Each of its measures is allied with all its others, so that it may be said to recapture that unity of harmony and efficiency which was the secret of past ages, the secret of Egypt, of Pythagorus, and so on through time to the eighteenth century when a decline becomes apparent.

Based on the golden mean, which is found in the proportion of the human body, it establishes an essential bond between the pure mathematical event and the determining factor of the building field—to construct a shelter for the body of man.

This rule is derived from a mathematical function related to the golden-mean series. From the measures of proportion it provides, extraordinary combinations can be derived.

Since the modulor will provide an abundance of measurements useful to the building field, and, more particularly, since it will guide and condition prefabrications, the place where these prefabrications will be made must be considered. Human stature, too, on which the primary measurements of the modulor are based, must be considered. The standard adopted must be suited to short as well as tall people.

The basic measurement adopted here is six feet (72 inches), since it is believed to be typical of the stature of the northern peoples. Its metrical equivalent is 182.9 cm. By deduction, from this basic measurement, the values of the modulor are determined as: Solar plexus = 44.498 in., or 1130.3 mm; upraised arm = 88.997 in., or 2260.5 mm. These three values, taken from the position on the human figure of the top of the head, the solar plexus, and the extremity of the fingers when the arm is raised, determine the gradations.

In its practical application to the known requirements of a problem, the modulor can be seen as the materialization of a linear event. For example, the modulor can be seen as a ruled ribbon, printed or engraved, rigid or supple, capable of being either rolled or folded. One of its sides reproduces in true scale the modulor gradations between zero and 2.26 meters (89 inches), the length determined by the height of the man with upraised arm. Each of its divisions and subdivisions are made according to the laws of proportion governing the whole. In the hands of the architect, the engineer of the industrial designer, or whoever deals with the problems of design, the modulor brings an immediate materialization of degrees of proportion, inherent in which are a "real flowering of the harmonic combinations of the golden mean."

The other side of the modulor reproduces the gradations on two scales. (1) An architectural scale, at a reduction suitable to architectural projects; and (2) a town planning scale, at a reduction suitable to the projects of urbanism. Modulor proportions can also be translated into numerical tables, giving the exact dimensions in both meters and feet, up to, say, 1500 ft. From these, the designer would be enabled to apply the modulor system of proportions to meet requirements on any scale.

Thus it provides a series of measurements of proportion, capable of usefully guiding and conditioning all sorts of projects in the building field, whether the design problem is on the scale of the smallest household object, or on that of city planning itself.

It provides a rule of harmony on which to base the products related to building and through which to create a universality of dimension, particularly among those objects planned for prefabrication. The wealth of the combinations it offers precludes its being used as a tool of uniformity.

The modulor is a work tool and, as such, it is a companion to the compass and the pencil.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

"The Technical Man's Cause Is Not Hopeless"

To the Editor:

The technical man's cause is hopeless unless the technical man uses some of his brain's capacity to make himself known to the public.

A well-established lawyer or engineer, whether he has his own firm or is an executive controlling a large organization, can command a large income or salary, whereas the man who is employed in these professions can be lucky (in this country at any rate) if he receives a salary of about half of the earnings of a man on the water front for the same hours of actual work in his place of employment.

I take exception to the statement of Mr. Keefer[1] that "the young engineer without business training is frankly not very valuable, except potentially, to any concern." I hold that any qualified engineer is "the most valuable asset" that any engineering concern can have.

In my 12 years of practice in various concerns I have watched highly skilled engineers being kept at their drawing boards, laboratories, and calculating desks and being pumped out for information by the businessman who knows nothing about what he is selling, and who could not survive the professional engineer. It is this businessman, however, who makes the contacts with other firms and to them he dishes out all he has picked up from the man who thinks out, designs, and calculates all the products of our civilization. We engineers could make this world look very silly if we decided not to use our brains any longer and let the uneducated work out electronics and aerodynamics. The businessman uses us to evolve the goods he sells and he knows it very well. The public, however, does not know it, and it is time for the engineer to make himself and his work known to the public.

The medical profession stands on a different footing altogether. The majority of doctors have their own "business" and have associations that act as propaganda departments, telling the world, not in their own professional papers, but in the daily press and the films, what their men are doing. Since man is more afraid of dying than of not being able to have an efficiently working motorcar, it is easier for the doctor to keep his standard up.

I have drawn the medical profession into this argument not because I think they are commanding too big a return for their work, but because a qualified engineer, with his scientific knowledge, gained through years of study which he has to supply in such a way as to give his employer and the public the best results they are entitled to, according to the present latest scientific knowledge, should have a bigger share in the public's heart and in the monetary return for his brainwork.

To achieve this, I repeat, we have to make known to the public *who* designs their motorcars, airplanes, radio sets, and refrigerators, and *who* is responsible for their being able to turn on a water or gas tap, and pull a switch to light their homes. We also have to let them know what amount of scientific training is necessary to enable engineers to achieve results and even predict them. We should also see to it that it should not depend on the clever salesman to sell a product, but on the sincere engineer to produce quality that will sell itself.

E. Morgen.[2]

[1] "The Technical Man's Cause Is Not Hopeless," K. B. Keefer, Mechanical Engineering, vol. 68, 1946, p. 1085.

[2] East Melbourne, Victoria, Australia.

Electric Gaging Equipment

Comment by C. H. Gibbons[3]

This interesting paper[4] is valuable in that it focuses attention on the simplicity and ease of use of electric strain gages, particularly in routine testing or stress analysis where the ultimate precision of which the gages are capable is not required. The writer is pleased to note the authors' emphasis on the inadequacy of ordinary speech amplifiers even in cases, such as their own, where some measure of accuracy may be sacrificed to expediency.

As supplementing their report on load-sensitive devices, it may be in order to state that such devices are commercially available in capacities from $\frac{1}{2}$ lb to millions of pounds of load. One of these devices for a service demanding high precision is required to meet rigid specifications; the checks being made at the National Bureau of Standards on the dead-weight tester. This instrument, in association with its indicating means, regularly shows inaccuracies of less than 1 part in a capacity of 20,000.

An ordinary proving ring or elastic loop, such as normally used for calibration of testing machines, with strain gages cemented on at proper places, has been used to provide the load coordinate of a load-deformation graph on a cathode-ray-oscilloscope screen.

The authors' use of electric gages in an effort to determine loads on various areas of a human foot reminds us that a Navy project at one of our great universities involves the use of electric gages in a study in limb prosthesis.

Pressure-sensitive units are also available commercially from a fraction of 1 psi to 50,000 psi full scale, with experimental work progressing toward still higher pressures.

In the field of gages based upon principles of electromagnetism, commercially available stress-strain recorders employ that principle in the strain pickup element and, on occasion, use the same principle in the load (stress) pickup. Accelerometers and displacement-measuring devices based upon the same principle are also made. Electric strain gages are used as pickup elements to provide control of load application in certain machines for the fatigue-testing of materials.

The list could be extended, with new applications found or planned almost daily. A very interesting experimental application is one for the determination of blood-pressure variation in the various chambers of the heart itself.

[3] Eddystone Division, The Baldwin Locomotive Works, Eddystone, Pa.

[4] "The Use of Electric Gaging Equipment in Machine Design," by P. E. Nokes and F. G. Carr, Mechanical Engineering, vol. 69, 1947, pp. 117–118.

COMMENT BY J. H. MEIER[5]

While working along an entirely different field of endeavor, namely, that of observing the performance characteristics of large excavating machines under operating conditions, the writer has encountered essentially the same conditions as the authors. The primary object is to supply the design engineer with actual working loads. Heretofore, design engineers depended to a large extent upon experience and judgment in proportioning elements of their machines. Now it is possible to tackle many problems more accurately and effectively. The writer fully agrees with the authors that, for such purposes, supreme accuracy is not required. This is particularly true for equipment where working loads are generally not duplicated accurately; shoes as well as excavating machinery belong to this category. In such cases, an over-all accuracy of 5 to 7 per cent of the maximum observed working load seems ample. Within such tolerances, an amazing variety of relatively simple electrical pickup units can be designed, and problems that seemed far too complicated for practical solutions a few years ago can now be handled with ease.

The new gaging methods, which were so greatly advanced by the introduction of the SR-4 gages, have brought about a considerable reorientation in the field of experimental methods. The emphasis shifted to electrical equipment. Almost any function to be recorded from machinery can readily be translated into a voltage that is suitable for input into recording equipment. It is to be hoped that college courses for mechanical and civil engineers will soon take into account the great possibilities offered by electric gaging.

The authors point out that pickup units are not restricted to the use of resistance-wire strain gages. It is indeed very often possible to employ some other pickup means that tie directly into equipment which was primarily designed for strain-gage work. For instance, an alternative solution for the recording hand tachometer, shown in Fig. 4*A*, would be to employ a variable air-gap capacitor instead of the cam and spring with strain gages. If a linear capacitor (semicircular plates, rotating through 360 deg) is used, a saw-tooth wave is obtained. When the shaft rotates at constant speed, the individual portions of the wave are straight lines. Any change in shaft speed causes a deviation from the straight line and is readily apparent. The details of the rotation during individual revolutions are thus recorded in a most effective way.

Linear-displacement measurements, for which the authors show a leaf spring with strain gages in Fig. 4*B*, can also be achieved by a potentiometer with sliding arm. A pencil lead is well suited as resistor.[6] The particular choice of pickup device depends upon the judgment of the experimenter and, with some experience in this field, it is usually not hard to find the one which gives the desired results with a minimum of cost. The field is certainly an interesting one and new ideas are being developed continuously.

[5] Research Engineer, Bucyrus-Erie Company, South Milwaukee, Wis.

[6] "Some Aspects of Observing the Performance of Large Machinery Under Operating Conditions," by J. H. Meier, Experimental Stress Analysis, vol. 1, no. 2, Addison-Wesley Press, Cambridge, Mass., 1944.

AUTHORS' CLOSURE

The authors of this paper are extremely pleased with the interest shown in their effort. It would appear, from the comment received, that others have noted the extreme versatility of the apparatus involved and used it accordingly. Since it was the object of the paper to call this fact to the attention of designers and design engineers, it would seem that this object has been achieved.

We would particularly express our appreciation for the comments of Messrs. C. H. Gibbons and J. H. Meier and for the additional examples they contributed.

Wood-to-Metal Adhesives

COMMENT BY A. J. LACROIX[7]

We have been most successful in making wooden scales adhere to Dowmetal handles, as well as to steel blades of certain types, as stated in this paper.[8] In the matter of the blades to which we apply wooden handles, these were held formerly with tubular rivets and now many of them are glued on as indicated by the author.

In the case of the Dowmetal handles, the metal itself was tapped to receive four screws. This, of course, is an expensive operation. With the present method our costs are greatly reduced. We make about 75,000 of these wooden-handled knives per year. They are used almost exclusively in the Akron rubber mills.

In the case of the handle scales being applied to spatulas, butcher knives, or other blades which were formerly held with rivets, the saving is not as marked. In fact, in most cases, there is no saving at all. The finished tool, however, has a fine appearance, and the handle adheres closely to the blade and cannot be removed. If one tries to chisel a handle from the blade, invariably when it does come off part of the wood remains on the blade or the handle is completely broken before it is released.

While no immediate additional applications of this method are apparent at the moment, we expect to find other uses for it in the future.

[7] President, Hyde Manufacturing Company, Southbridge, Mass. Mem. A.S.M.E.

[8] "Wood-to-Metal Adhesives," by T. D. Perry, MECHANICAL ENGINEERING, vol. 68, 1946, pp. 1035–1040.

Flexible-Wall Wind Tunnel

TO THE EDITOR:

I have recently read in MECHANICAL ENGINEERING,[9] a description of the flexible-wall supersonic tunnel, of the Ordnance Department at Aberdeen, Md.

It may interest your readers to know that while working with the Technical Services of the French Air Ministry in Paris during the years 1937 to 1940, I designed and built a flexible-wall supersonic tunnel of the same type as described in the paper.

This tunnel, which had been in successful operation for several months until May, 1940, had a rectangular working section of 6 cm × 12 cm (average). It was of the open-circuit suction type, with the circulation of air produced by a 600-hp axial exhauster.

Mach numbers up to three have been reached and speeds very close to the speed of sound have been maintained.

Accumulated data from this tunnel, which has shown the considerable advantages of a flexible-wall type over all others, were to be used for the design of a much larger installation which was stopped by the invasion and the occupation of France in June, 1940.

B. A. RABINEAU.[10]

[9] "Supersonic Wind Tunnel Laboratory," by G. M. Barnes, MECHANICAL ENGINEERING, vol. 67, no. 12, December, 1945, pp. 827–833 and 835.

[10] Long Beach, Calif.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Introduction to Aerodynamics of a Compressible Fluid

INTRODUCTION TO AERODYNAMICS OF A COMPRESSIBLE FLUID. By Hans Wolfgang Liepmann and Allen E. Puckett. John Wiley & Sons, Inc., New York, N. Y., 1947. Cloth, 5³/₄ × 9 in., 262 pp., illus., and charts, $4.

REVIEWED BY R. C. BINDER[1]

THIS timely book is an excellent introduction to the aerodynamics of a compressible fluid. It is one of the GALCIT[2] aeronautical series edited by Professors Theodore von Kármán and Clark B. Millikan. It should be of particular, direct help to workers in aeronautical engineering and of interest and value to those in related fields.

Compressible flow has become rather important during the last few years and has provoked much attention and interest. The problems of high-velocity flow that have arisen in practice are very difficult; the theoretical analysis and experimentation are very complicated and sometimes troublesome. The previous literature has been sadly lacking in completely organized material. For example, much of the information has been scattered in different publications. Some papers are in a foreign language, and some have not been easily accessible. Liepmann and Puckett have provided a well-organized and systematic treatment which includes recent developments. The presentation is sound and accurate. The level is that of a graduate course. Emphasis is almost exclusively upon the derivation and the meaning of the fundamental aerodynamics relations.

The first part of the book deals with one-dimensional flow and includes chapters on basic thermodynamics, equations of motion, isentropic channel flow, shock waves, applications to channel flow, and optical methods of flow observation. There is a discussion of flow in a Laval nozzle, of supersonic wind-tunnel design, the schlieren method, and the shadow method. The treatment is primarily analytical, for a frictionless fluid. Part 1 helps to bring out many of the characteristic features of the subsonic and supersonic flow of a perfect gas with a minimum of mathematical complication.

The sections on Mach waves and shock waves make clear a number of features which are frequently confused.

The second part of the book deals with the more complicated problems of two-dimensional and three-dimensional flow. The basic equations, as continuity and momentum, are first set up, and the major difficulties of integrating nonlinear partial differential equations pointed out. Then the various more common methods of solution are detailed, and the results interpreted. Part 2 includes chapters on the small-perturbation method, some applications of the small-perturbation method, the development of the velocity potential in different power series, the hodograph methods, certain exact solutions, the method of characteristics, the effects of viscosity, and airfoils in high-speed flow and some comparison with experiment. The treatment is quite mathematical, considering mainly the isentropic flow of a perfect gas. The viscosity effects are pointed out in a qualitative manner. Specific sets of test data are not included because of remaining wartime restrictions and the present unsettled state of high airspeed testing techniques.

Various approximate methods of solutions are explained, as those by Prandtl-Glauert, Rayleigh-Janzen, Chaplygin, Kármán-Tsien, and Kármán. These methods have been of real concern to aeronautical engineers confronted with high-speed flight. The co-ordinated discussion should be of much help to one approaching such problems. A simple example of flow past a wave-shaped wall is given; it is very effective in bringing out two-dimensional effects in the subsonic and supersonic regions. There is detailed the application of the method of characteristics to supersonic nozzle design. Many interesting and intriguing features are brought out about flow in the three regimes, the subsonic, the transonic, and the supersonic.

The double purpose of the book is to help the reader understand observed compressibility effects and to prepare him for the more mathematical literature of the subject. The authors have realized their objective in a well-written book.

[1] Professor of Mechanical Engineering, Purdue University, West Lafayette, Ind. Mem. A.S.M.E.

[2] Guggenheim Aeronautical Laboratory, California Institute of Technology.

Explosion and Combustion Processes in Gases

EXPLOSION AND COMBUSTION PROCESSES IN GASES. By Wilhelm Jost, Leipzig, Germany, 1935. Translated by Huber O. Croft. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1946. First edition. Cloth, 6 × 9 in., 621 pp., 277 figs., $7.50.

REVIEWED BY H. DEAN BAKER[3]

THIS translation of Jost's book makes available in English one of the few comparable volumes presenting basic data and theory of explosion and combustion processes in gases. Although originally written prior to 1935, and therefore by no means up to date, this volume is valuable as an exposition of the state of knowledge existing at that time.

Jost deals in a fundamental way with the phenomena of ignition, flame propagation, and detonation in and radiation from combustible mixtures. Material drawn from the sciences is developed from general principles in a manner which brings all sections of the book within the range of anyone having a thorough grasp of elementary physics, chemistry, and integral calculus.

Although an attempt is not made to draw on the mass of personal experience and trade information in industry, published experimental evidence is reviewed with an unusually meticulous degree of detail. The author presents and criticizes alternative theories—frequently without reaching definite conclusions. Jost has, however, helped to organize the material and indicate an approach toward a valid body of theory.

The first quarter of the book contains a purely classical explanation of ignition and propagation of explosions, i.e., mixture proportions, pressure, and temperature as determining the reaction rate computed from ordinary heat-conduction

[3] Assistant Professor, Department of Mechanical Engineering, Columbia University, New York, N. Y. Mem. A.S.M.E.

methods. In the analysis of experimental evidence the inadequacies of such simplified theory are occasionally pointed out. After discussing detonation phenomena in terms of shock-wave theory and detailed experimental evidence, eight pages are devoted to diffusion flames.

The author then proceeds with more basic questions. Fundamental concepts and formulations of chemical kinetics, kinetic theory of gases, and quantum mechanics are briefly developed. In the last half of the book he takes up ignition, combustion of hydrocarbons, and detonation in terms of this more complete theory, supplemented by masses of detailed experimental data. The chapter on Otto engines is essentially a discussion of knocking; the chapter on Diesel engines is primarily concerned with ignition.

Those engineers whose expectations are determined by the publisher's descriptive phrase, "A translation of the classic German work on jet propulsion . . ." may be disappointed in the contents of this book, since it contains no discussion of jet propulsion as such. Likewise, those engineers who might hope to find in Jost new proposals, formulas, and rules for the design, development, or operation of burners, furnaces, or internal-combustion engines may find it of no help. Out of the six-hundred pages, only a total of ninety pages deals with subject matter directly relevant to industrial equipment.

Moreover, the condensed style, the large quantity of detail, the frequent lack of definite conclusions, and the unfortunate number of small errors tend to make the book difficult reading.

With all its inadequacies, this book is nevertheless an important addition to the available literature. Jost has performed a notable job of summarizing and analyzing the established knowledge relevant to explosion and combustion phenomena in gases.

Ceramic Whitewares

CERAMIC WHITEWARES.* By Rexford Newcomb, Jr. Pitman Publishing Corporation, New York, N. Y., 1947. Cloth, 6 × 9 in., 308 pp. and index, illus., $5.

REVIEWED BY W. KEITH MCAFEE[4]

THIS book is a general introduction to the "whiteware" branch of the ceramic industry. The term includes various types of pottery, porcelain, and china. The first chapter is a brief historical account of pottery making and is written by Carlton Atherton of Ohio State University.

The author then discusses the fundamental elements of the basic ceramic processes involved and the more important raw materials used. Then the fundamental steps in whiteware fabrication are dealt with, including glazing and decorating.

The closing chapters cover basic fields of application: sanitary ware and floor and wall tile in construction; tableware and cooking ware in the home; and various types of electrical, chemical, and refractory porcelain in industry. The final chapter deals with abrasives and abrasive wheels, and is followed by an appendix comprising six to eight questions or exercises on each chapter.

The book should prove useful to those desiring a brief, general treatise on this branch of the ceramic industry, and to teachers of introductory courses in ceramics.

[4] President, Universal Sanitary Manufacturing Company, New Castle, Pa. Mem. A.S.M.E. and American Ceramic Society representative to Process Industries Division.

Books Received in Library

AIRCRAFT LAYOUT AND DETAIL DESIGN. By N. H. Anderson, with a foreword by C. T. Reid. Second edition. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. Cloth, 5 × 8½ in., 437 pp., illus., diagrams, charts, tables, $4.50. This text covers the three main subjects with which aircraft-layout draftsmen must be familiar: the portions of descriptive geometry that have common application to aircraft structures are discussed; specific directions are given for detail design which will simplify the shopwork for producing the parts; and a treatment of stress analysis is given, sufficient to enable the draftsman to design intelligently parts having the required strength with a minimum of weight. New information has been added in this edition on the design of forgings and castings, principles of equilibrium, and the mechanical properties of materials.

ANALYSIS OF RAILROAD OPERATIONS. By J. L. White. Simmons-Boardman Publishing Corporation, New York, N. Y., 1946. Cloth, 6 × 9¼ in., 305 pp., illus., diagrams, charts, tables, $5. Statistical and accounting procedures necessary for effective analysis are dealt with in full, with detailed discussion of character of the revenues and expenses to be considered. The main text concludes with analysis of actual operations of two Class 1 railways in 1941, including the tabular presentation of important information. The book is intended to serve a wide field, from the student of railroad transportation to the security analyst, but particularly for railroad executives, accountants, and operating officers.

APPLIED ENGINEERING MECHANICS. By A. Jensen. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1947. Cloth, 6 × 9¼ in., 316 pp., diagrams, tables, $3. This book is intended to provide a text that meets the minimum requirements of the usual college course but needs only an understanding of high-school mathematics. Mathematical manipulations have been replaced in large part by basic scientific reasoning from the physical concepts. The book is divided into the customary two sections, statics and dynamics, with a logical gradation from the elementary to the more involved concepts in each case. Analytical and graphical solutions are presented side by side to show relationship and encourage the student to check one against the other.

ATLAS OF DEFECTS IN CASTINGS. Series I. Institute of British Foundrymen, Manchester, England, 1946. Stiff paper, 6½ × 10 in., 34 pp., illus., 10s, 6d. Some forty casting defects are covered in this first series of descriptive sheets which are intended to assist ferrous and nonferrous foundrymen in the recognition and classification of such defects. Each sheet contains a photographic example of the defect with explanatory text, a statement of the cause or causes, and suggested remedies.

BASIC ENGINEERING DRAWING. By H. D. Orth, R. R. Worsencroft, and H. B. Doke. Irwin-Farnham Publishing Company, Chicago, Ill., 1946. Cloth, 6 × 9¼ in., 346 pp., illus., diagrams, charts, tables, $3.50. Also PROBLEMS IN BASIC ENGINEERING DRAWING. By H. D. Orth, R. R. Worsencroft, and H. B. Doke. Same publisher, 1946. Stiff paper, spiral binding, 9¼ × 11 in., no pagination, diagrams, tables, $2.50. The object of this text is to present the fundamentals of the subject in a logical sequence that will properly develop both the theory and the necessary manual skill. The early chapters cover instruments and materials, the basic methods of representation, lettering, and technical sketching. Succeeding chapters deal with instrumental drawing methods, tracing, geometrical constructions, dimensioning, graphs and charts, and the detailed representation of machine parts and instructions as for working drawings. A large group of drafting problems together with complemental problems in theory is contained in a separate work book.

CAR BUILDERS' CYCLOPEDIA OF AMERICAN PRACTICE. Seventeenth edition., 1946. Compiled and edited for the Association of American Railroads, Mechanical Division; editors, R. V. Wright, R. C. Augur, and others. Simmons-Boardman Publishing Corporation, New York, N. Y. Cloth, 8 × 12 in., 1444 pp., illus., diagrams, charts, tables, $6. The new edition of this well-known reference book again brings up to date the record of American car designs and car equipment. As before, the material is arranged in classified sections with bibliographies of selected descriptive articles from *Railway Age* and *Railway Mechanical Engineer*. Car parts, trade names, and advertisers are indexed and there is a 60-page dictionary of car terms.

COMBUSTION AND MODERN COAL-BURNING EQUIPMENT. By J. L. Catton. Sir Isaac Pitman & Sons, Ltd., London, England; Pitman Publishing Corporation, New York, N. Y., 1946. Cloth, 5½ × 9¾ in., 121 pp., illus., diagrams, tables, $4.20. This small volume presents a review of modern progress in controlling the process of combustion, together with the description of the mechanical appliances and devices employed in the economic consumption of solid fuel for industrial and domestic uses. Special topics covered include

automatic stoking, automatic boiler control, chimneys, and draught.

DESIGNS FOR HELICOPTERS. By I. B. Laskowitz, apply to author, 284 Eastern Parkway, Brooklyn 25, N. Y., 1947. Paper, 8 × 10½ in., 23 pp., diagrams, $2. This pamphlet contains patent specifications and drawings of an application now pending, giving details of three different designs for helicopters with manual and automatic blade-pitch-angle changing means.

ELEMENTS OF HYDRAULIC ENGINEERING. By D. S. Ellis. D. Van Nostrand Company, New York, N. Y., 1947. Cloth, 6 × 9¼ in., 277 pp., diagrams, charts, tables, $3.50. Chapters 1 to 10 present a concise treatment of the basic ideas and methods of hydraulics, from hydrostatics to the dynamic effects of fluids, customary for a first course in the subject. The remainder of the book is concerned with the operating characteristics of the commoner hydraulic machines such as pumps, water wheels, and fans, and with such special topics as water hammer, waves and surges in open channels. The author uses these topics, as examples of hydraulic application, in combination with the theory to form a one-year course for mining, metallurgical, and chemical-engineering students.

ELEMENTS OF MECHANISM. By P. Schwamb, A. L. Merrill, and W. H. James. Sixth edition, revised by V. L. Doughtie. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1947. Cloth, 5¾ × 9½ in., 428 pp., illus., diagrams, charts, tables, $4. This standard textbook gives the fundamental principles of kinematics in the field of mechanical movements. Principal machine elements are selected, and a study is presented of their motions when combined in certain ways. The early chapters cover motion in general, vectors, velocity and acceleration analysis, and linkages. Cams, gears, and belts are discussed in detail in the later chapters. This new edition includes for the first time a group of laboratory problems emphasizing practical applications.

ENGINEERING ECONOMICS AND PRACTICE, including Solutions to Problems in Professional Engineering Examinations, New York State. By M. J. Steinberg and W. Glendinning. Apply W. Glendinning, 5123 Bell Boulevard, Bayside, New York, 1947. Cloth, 8½ × 11½ in., 101 pp., diagrams, charts, tables, $3. This book covers the basic principles of engineering economics and practice. The principles have been reduced to a formula basis with each of the terms clearly defined. Each chapter includes problems of a practical nature that illustrate the principles involved. Questions and solutions to the problems in engineering economics and practice from the New York State Professional Engineering examinations are an important supplement to the text material.

ENGINEERING PROBLEMS MANUAL. By F. C. Dana and L. R. Hillyard. Fourth edition. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1947. Cloth, 6 × 9¼ in., 419 pp., illus., diagrams, charts, tables, $3.25. As in previous editions of this book, the purpose has been to offer a student manual for the engineering-problems course. The material is based upon practical engineering situations and aims to co-ordinate the work in algebra, trigonometry, and calculus and to develop good habits of work and study toward the attainment of a high degree of clearness and accuracy in calculation. The problems have been selected from a wide variety of applications and many new ones have been added in the present edition. The book has undergone considerable general revision.

HEATING, VENTILATING, AIR CONDITIONING GUIDE, 1947, vol. 25. Technical Data Section and Manufacturers' Catalog Data Section, also Roll of Membership of the Society, with Complete Indexes. American Society of Heating and Ventilating Engineers, New York, N. Y., Fabrikoid, 6 × 9¼ in., 1282 pp., plus 128 pp., illus., diagrams, charts, tables, $6. This standard manual constitutes both a textbook and handbook on the design and specification of heating, ventilating, and air-conditioning systems. The technical section has been thoroughly revised, and new material has been added, particularly in the chapters on heating and cooling loads. There is also a new section describing the air-refrigeration cycle. It provides all the data ordinarily needed by engineers and architects, cross-indexed for quick reference. The catalog section contains information on the products of over two-hundred manufacturers, with a classified index.

HOUSE OUT OF FACTORY. By J. Gloag and G. Wornum. The Macmillan Company, New York, N. Y. George Allen & Unwin, Ltd., London, England, 1946. Cloth 5½ × 8¾ in., 144 pp., diagrams, tables, $3. The authors deal with the whole problem of the prefabricated (factory-produced) house, past, present, and future. Topics covered include design and appearance; materials and mechanical equipment; constructional principles; cost, comfort, and durability considerations; and the advantages and possibilities of factory production. The text is illustrated by a large number of sketches, detail drawings, and photographs.

HYDRAULIC MEASUREMENTS. By H. Addison. Second edition, revised and enlarged. John Wiley & Sons, Inc., New York, N. Y., 1946. Cloth, 5½ × 8¾ in., 327 pp., illus., diagrams, charts, tables, $5. This manual for engineers is an amplification of the last chapter of the author's "Textbook of Applied Hydraulics." Wholly practical in treatment, the book covers the measurement of both open channel flow and flow in pipes and conduits. It deals with liquids only, omitting any discussion of gas metering. The final chapter covers indicating, recording, and integrating instruments. There is a bibliography.

INTRODUCTION TO ATOMIC PHYSICS. By H. Semat. Revised and enlarged. Rinehart and Company, New York, N. Y., 1946. Cloth, 6 × 9¼ in., 412 pp., illus., diagrams, charts, tables, $4.50. It is the aim of this book to present the important experimental data upon which are based the present ideas of the structure of the atom. Part 1 discusses the foundations of atomic physics, beginning with the elements of electricity and magnetism and continuing with detailed information on electromagnetic radiation, waves, and particles. Part 2 covers the extranuclear structure of the atom, while Part 3 deals with the nucleus itself and with nuclear energy. The major part of the revision is in Part 3, with several new topics included, such as the discovery of new elements and the measurement of nuclear magnetic moments.

INTRODUCTION TO ENGINEERING PLASTICS. By D. W. Brown and W. T. Harris. Murray Hill Book Co., Inc., Technical Division, New York, N. Y., and Toronto, Ontario, Can., 1947. Cloth, 6 × 9¼ in., 274 pp., illus., diagrams, charts, tables, $4. A detailed account is given of the various plastics that have found commercial acceptance. Chapters are included on the engineering properties and the chemical and physical characteristics of plastics; applications and techniques in handling plastics; and a list of the types of plastics with trade names and manufacturers. The authors have also furnished plant and equipment data, design considerations, and commercial tolerances.

MAGNESIUM FABRICATION. By L. B. Harkins. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1947. Cloth, 6 × 9¼ in., 149 pp., illus., diagrams, charts, tables, $2.75. This practical handbook presents authoritative data for all phases of the fabrication of magnesium-alloy sheet, extrusions, and tubing into the finished product. Important topics covered include machining, forming, heat-treating, welding, joining, surface finishing, and protection. The techniques peculiar to magnesium are emphasized, together with notes on fire control and protection against corrosion. The major producers and fabricators in the industry are listed.

MEASURING AND RATING EMPLOYEE VALUE. By J. B. Probst. Ronald Press Company, New York, N. Y., 1947. Cloth, 6 × 9¼ in., 166 pp., diagrams, charts, tables, $5. Traditional methods of employee rating are first discussed briefly to point out what are considered to be their inherent defects and causes of their failure. The book next develops the setting up of the characteristics fundamental to the measurement and rating of employee value, explaining these characteristics and the manner in which they are individually measured so that they may be correctly scored in the rating plan devised by the author on a basis of extensive study and experimentation. Numerous examples of the actual application of the methods in a variety of occupations are given, with statements of the results obtained from later checks of the ratings in actual practice.

MECHANICAL VIBRATIONS. By J. P. Den Hartog. Third edition. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1947. Cloth, 6 × 9¼ in., 478 pp., diagrams, charts, tables, $6. The present edition of this well-known book deals with vibration phenomena in a thoroughly technical manner, while emphasizing the many applications of principles and calculations to the practical vibration problems encountered by the engineer. All material has been brought up to date, and a new chapter on helicopter ground vibrations has been added. As in previous editions, complete explanations and proofs are given, without employing mathematics higher than simple differentiations and integrations. There is a bibliography.

METAL WORKING AND HEAT-TREATMENT MANUAL, vol. 2. Alloy Steels, Cast Iron, and Nonferrous Metals. By F. Johnson. Paul Elek Publishers, Ltd., London, E.C.1, England, 1947. Cloth, 5½ × 8¾ in., 226 pp., illus., diagrams, charts, tables, 17s,6d. This is the second volume in a series of four to cover the entire range of heat-treatment of metals. Beginning with a brief résumé of steel-making processes, the book continues with detailed description of the important steel alloys and the characteristics imparted by various alloying elements and heat-treatments. Two chapters are devoted to the composition and treatment of cast iron and the alloys of copper with zinc, tin, and aluminum. Tables and diagrams are extensively used for the effective presentation of mechanical and metallurgical data. The final chapter deals with the phenomena of age-hardening in various alloys.

METALLURGICAL MATERIALS, Alloys and Manufacturing Processes. By V. N. Wood, with a foreword by J. W. Gardom. Chapman & Hall, Ltd., London, England, 1946. Cloth,

$5^1/_2 \times 8^3/_4$ in., 340 pp., illus., diagrams, charts, tables, 25s. Early chapters deal with the manufacture of iron and steel, mechanical testing, and the physical examination of metals. Chapters follow on industrial control and measurement of temperature, heat-treatment, carbon and alloy steels, and the mechanical working of steel. Cast iron, malleable cast iron, and the nonferrous metals and alloys are covered, with a final chapter on miscellaneous processes such as welding, galvanizing, powder, metallurgy, etc. The aim of the author is to provide a comprehensive, practical text and reference book for metallurgical students and workers in the metal industries.

OIL HEATING HANDBOOK. By H. A. Kunitz. Third edition, revised. J. B. Lippincott Co., Philadelphia, Pa., and London, England, 1947. Cloth, $5 \times 7^3/_4$ in., 464 pp., illus., diagrams, charts, tables, $5. Following an introductory section describing oil-burner systems and types, this manual is divided into four parts: fuels and combustion; heating and heating systems, including operative controls; installation and operation of oil burners; retail sales. The object is to provide a manual of theoretical and practical considerations entering into the manufacture, installation, and use of oil burners in moderate-size heaters. A section of forms and tables is appended, accompanied by a thirty-page glossary of terms.

RESISTANCE WELDING MANUAL (Revised Edition). Published by Resistance Welder Manufacturers' Association, Philadelphia, Pa. 1946. Cloth, $5^3/_4 \times 9^1/_4$ in., 544 pp., illus., diagrams, charts, tables, $3. The introductory section of this Manual covers technical and economic fundamentals. Section 2 describes in detail the various resistance-welding processes. The resistance-welding characteristics of various important metal groups are considered separately in Section 3, with information on how these characteristics affect welding procedures. Mechanical and electrical characteristics of welding machines are also covered in this section. Sections new in this revised edition deal with inspection, testing, and quality control, and with maintenance of equipment. Useful data tables and a glossary are appended.

REVIEW OF METAL LITERATURE, vol. 2, 1945, prepared for the Members of the American Society for Metals by Battelle Institute, Columbus, Ohio, published by American Society for Metals, Cleveland, Ohio, 1946. Cloth, $6 \times 9^1/_4$ in., 813 pp., $15. This annotated survey lists articles and technical papers appearing in engineering, scientific, and industrial journals, both here and abroad. The present volume is a collection of the installments from February, 1945, through January, 1946, of the *Review of Current Metal Literature* which appears in *The Metals Review* and covers the metallurgical literature of 1945. The annotations are classified in sections primarily by processes: smelting and refining, powder metallurgy, electroplating, heat-treatment, etc. There are also a detailed subject index, an author index, addresses of magazines covered, and an annotated list of technical books published within the period covered.

RUSSIAN-ENGLISH TECHNICAL AND CHEMICAL DICTIONARY. By L. I. Callaham. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1947. Fabrikoid, $5^1/_2 \times 8$ in., 794 pp., $10. Originally planned to cover the chemical and process industries, this dictionary has been expanded to give comprehensive coverage of mineralogy, metallurgy, mining and geology, general engineering, machinery and mechanics, electrical engineering, pharmacy, and botany. Frequently used terms are also included for aeronautics, agriculture, medicine, physics, mathematics, and other scientific fields. A general vocabulary is included in the same alphabet, together with a large number of prefixes and suffixes. American usage and spelling are followed rather than British in the English equivalents.

STEAM GENERATION. By J. N. Williams. Evans Bros., Ltd., Montague House, London, England, 1946. Cloth, $5^1/_4 \times 8^1/_2$ in., 372 pp., illus., diagrams, charts, tables, 25s. Beginning with the theory and basic practice of combustion, this practical work covers the subject of boiler maganement in a comprehensive manner. Basic and auxiliary equipment is described; boiler operation is dealt with; oil fuel, coal, pulverized fuel, coke, and breeze are covered; and feedwater treatment is discussed. Separate chapters are devoted to heat transmission, automatic boiler control, and flue-gas cleaning.

STEAM TURBINE AND OTHER INVENTIONS OF SIR CHARLES PARSONS. By R. H. Parsons. Published for the British Council by Longmans, Green & Company, London, England, New York, N. Y., Toronto, Ont., Can. Paper, $5 \times 7^1/_4$ in., 33 pp., illus., 1s,6d. This pamphlet describes the work of Sir Charles Parsons chiefly with respect to the steam turbine and the turbogenerator but also with regard to propellers, gearing, and optical work. Something of his life and character is also included.

STORY OF WOOL. By W. F. Leggett, with a foreword by S. I. Stroock. Chemical Publishing Company, Brooklyn, N. Y., 1947. Cloth, $5 \times 7^3/_4$ in., 304 pp., illus., $5. Beginning with brief information about sheep and their origin and the main types of wool fabrics, this book continues with short historical descriptions of the use and treatment of wool products in numerous countries, both ancient and modern. Other producers of wool or wool-like fibers are discussed, such as the camel, llama, and goat. The cloth guilds of Europe and England are considered, as a part of the general picture of the development of the wool industry from the earliest times.

SYMPOSIUM ON TESTING OF BEARINGS, 49th Annual Meeting of American Society for Testing Materials at Buffalo, N. Y., June 24–28, 1946. Published by American Society for Testing Materials, Philadelphia, Pa., 1947. Paper, 6×9 in., 65 pp., illus., diagrams, charts, tables, $1.50; to A.S.T.M. members, $1.15. The five papers included in this symposium deal with the life testing of plain bearings for automotive engines, testing under controlled load, fatigue testing of ball and roller bearings, and metallographic observations of ball-bearing fatigue phenomena. The discussion accompanies each paper.

SYNTHETIC FIBER DEVELOPMENTS IN GERMANY, compiled and edited by L. H. Smith. Textile Research Institute, New York, N. Y., 1946. Cloth, $6 \times 9^1/_4$ in., 1042 pp., illus., diagrams, charts, tables, $10. Supplement, 1946. Paper, $8^1/_2 \times 11$ in., charts 1–22, diagrams. The report of a group of qualified investigators, this publication describes general textile conditions in Germany and gives a detailed account of the viscose, acetate, and cuprammonium rayon processes as employed there. Fiber production, properties, and testing are covered as well as new research and development trends. There is a chapter on fully synthetic fibers; detailed data, graphs, and pictures are included throughout the book; and there is a separate supplement of 22 large drawings of machinery and flow sheets.

SYSTEMATIC MOTION AND TIME STUDY. By M. E. Mundel. Prentice-Hall, New York, N. Y., 1947. Cloth, $6 \times 9^1/_4$ in., 232 pp., illus., diagrams, charts, tables, $4.; text edition, $3. This new book presents the basic elements of time and motion study, demonstrates actual jobs and cases with resultant benefits, and discusses what results may be expected from effective application of the advocated principles. The necessary charts, graphs, and records are described and illustrated, and considerable space is devoted to the separate steps in the taking of a stop-watch time study. Ratings, allowances, and standards are covered, as are process analysis and layout.

TABLES OF THE BESSEL FUNCTIONS OF THE FIRST KIND OF ORDERS ZERO AND ONE. (Annals of the Computation Laboratory of Harvard University, Vol. 3.) TABLES OF THE BESSEL FUNCTIONS OF THE FIRST KIND OF ORDERS TWO AND THREE. (Annals of the Computation Laboratory of Harvard University, Vol. 4.) Harvard University Press, Cambridge, Mass.; Geoffrey Cumberlege, Oxford University Press, London, England, 1947. Cloth, 8×11 in., no pagination, tables, $10 each volume. Continuing a series of publications by the Harvard Computation Laboratory, these two volumes present detailed tables to 18 decimal places for a range of argument from 0 to 100, with an argument interval of 0.001 up to 25 and of 0.01 above 25. The volume covering the orders zero and one contains also an introductory discussion of Bessel functions, a description of the computational techniques, and the method of interpolating within the tables. The computation was done by the Automatic Sequence Controlled Calculator, the operation of which was described in volume 1 of the series.

TALKS ABOUT STEELMAKING. By H. Brearley. American Society for Metals, Cleveland, Ohio, 1946. Cloth, $6 \times 9^1/_4$ in., 236 pp., illus., diagrams, charts, tables, $3.50. A steelman discusses informally a wide range of topics within his field. From the chemical laboratory to the work bench, from the melting furnace to the forge shop, from the handling of materials to the handling of men, the author finds something of interest to be considered. As often as not, he ends his chapters with questions, real or implied, which are more or less a challenge to the industry.

TECHNICAL DICTIONARY, DIZIONARIO TECNICO, English-Italian, Italian-English. By G. Marolli. Felice Le Monnier, Florence, Italy, 1946. Stechert-Hafner, New York, N. Y., Cloth, 5×7 in., 466 pp., $7.50. This handy-sized dictionary lists the equivalents of scientific and technical terms from English to Italian and vice versa. Separate usages of terms in various fields are indicated. A list of abbreviations is given in each language, and a few standard conversion tables are included.

THEORY OF FUNCTIONS, PART 2. By K. Knopp, translated by F. Bagemihl. Dover Publications, New York, N. Y., 1947. Cloth, $4^1/_4 \times 6^3/_4$ in., 150 pp., illus., diagrams, $1.50. The foundations of the general theory of analytic functions having been established in Part 1, the present volume, translated from the German, deals mainly with special functions. These are split into two fundamental groups: single-valued functions, covering entire and meromorphic functions, simply periodic functions, and doubly periodic including elliptic functions; multiple-valued functions covering Riemann surfaces, algebraic functions, and the concept of analytic figuration. No attempt has been made to cover the whole field of the theory of functions, but to

select several particularly characteristic and important types.

THERMAL INSULATION OF BUILDINGS. By P. D. Close. Reinhold Publishing Corporation, New York, N.Y., 1947. Paper, 6 × 9 in., 104 pp., illus., diagrams, charts, maps, tables, $1.75. General theory and basic principles are followed by information on the calculation of heat losses and the estimation of fuel savings. The prevention of condensation is considered at some length. The types of manufactured insulations are described together with methods of application. The insulation of farm buildings other than residences is dealt with in a separate chapter. Lists of trade names, manufacturers, and trade associations are appended.

TIMBER DRYING and the Behavior of Seasoned Timber in Use. By R. G. Bateson. Second edition. Crosby Lockwood & Son, London, England, 1946. Cloth, 5 1/2 × 8 1/2 in., 129 pp., illus., diagrams, charts, tables, 10s, 6d. The principles of timber drying are explained and methods and equipment for both air-seasoning and kiln-seasoning are described in practical detail. Specific problems are discussed with their solutions, and one chapter is devoted to the behavior of seasoned timber in use.

TRICOT FABRIC DESIGN. By T. H. Johnson. McGraw-Hill Book Company, Inc., New York, N. Y., and London, England, 1946. Cloth, 5 1/2 × 8 1/4 in., 124 pp., illus., diagrams, tables, $2.50. In the opening chapters the elements and action of the tricot knitting machine are described with illustrative diagrams. Succeeding chapters discuss in detail the formation of the basic pattern types, with drafting and design detail. Separate chapters deal with graphic design and the important topic of runproof construction.

WATER CIRCULATION IN STEAM BOILERS, (*Mechanical World* Monographs 24). By J. Webster. Emmott & Co., Manchester, England, 1946. Paper, 5 × 7 in., 60 pp., diagrams, tables, 2s, 6d. This pamphlet deals briefly with the practical aspects of water circulation and steam generation in various types of boilers, the principles and practice of forced circulation, and the conditioning of boiler feedwater. Diagrams are freely used to illustrate and supplement the text.

WELDING SYMBOLS. By V. C. Gourley. Bruce Publishing Company, Milwaukee, Wis., 1947. Cloth 5 1/2 × 8 3/4 in., 115 pp., illus., diagrams, tables, $2.50. The general standards for the use of arc-, gas-, and resistance-welding symbols are explained in a simple graphic way. Illustrations consist of two parts: the drawing specifies the weld in the same manner as an actual mechanical drawing or blueprint; the explanation interprets the drawing, showing pictorially the exact location and outline of the weld. The standards and symbols demonstrated are the ones recognized by the American Welding Society. An illustrated glossary is included.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code may communicate with the Committee Secretary, 29 West 39th St., New York 18, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of March 28, 1947 and approved by the Council on April 18, 1947.

CASE No. 1033

(Annulled)

CASE No. 1040

(Withdrawn)

CASE No. 1041

(Special Ruling)

Inquiry: Is it permissible under the Code to employ cast steel of the composition and physical properties given below for high-temperature valves for service at 1000 F:

Carbon, per cent	0.20–0.30
Manganese, per cent	0.45–0.65
Silicon, per cent	0.25–0.55
Phosphorus, max, per cent	0.045
Sulphur, max, per cent	0.05
Chromium, per cent	0.40–0.70
Nickel, per cent	0.75–1.05
Molybdenum, per cent	0.85–1.05
Tensile strength, min, psi	85,000
Yield point, min, psi	60,000
Elongation, min, per cent	20
Reduction in area, min, per cent	40

Reply: It is the opinion of the Committee that the steel specified above may be used for the purpose stated provided that in other respects it meets the requirements of Specification SA-217, Grade WC4, except that the drawing temperature be 1300 to 1325 F. Also, if any welding is to be done on these valves, the welding procedure and welding operator shall be qualified under the rules of Section IX of the Code. The permissible stresses for this material shall not exceed those given for Grade WC4 of Specification SA-217.

CASE No. 1045

(Special Ruling)

Inquiry: The A.S.T.M. has recently issued new Specifications for Low and Intermediate Tensile Strength Carbon Steel Plates of Flange and Firebox Qualities (A 285–46) which replaces Specifications A 70 and A 89. Is it permissible under the Code to use material complying with A.S.T.M. Specifications A 285–46 as a substitute for material conforming to Specifications SA-70 and SA-89?

Reply: It is the opinion of the Committee that pending the adoption of A.S.T.M. Specifications A 285–46, material complying with Grades A and B of that specification may be used as the equivalent for material complying with Specifications SA-89, Grades A and B, respectively, and Grade C of that specification may be used as the equivalent for material complying with Specification SA-70.

CASE No. 1046

(Special Ruling)

Inquiry: Is it the intent of the Code (except for Section IV) that qualification tests be made of operators of automatic welding machines?

Reply. It is the opinion of the Committee that for automatic welding processes, each machine operator* shall make procedure qualification test plates of the maximum thickness to be used, of similar material (killed, semikilled, or rimmed), and the same machine setting. The test plates shall be tested and meet the requirements of Section IX, Pars. P-102, L-102, and U-68 for the type of vessel to be constructed.

CASE No. 1047

Interpretation of Table P-5

Inquiry: The allowable working stresses for Specification SA-213, Grade T22, have been omitted for temperatures over 900 F in Table P-5. Is this a typographical error?

Reply: Yes. The same allowable working stresses for Specification SA-213, Grade T22, for temperatures over 900 F should appear in Table P-5 as those given in Table P-7. These stresses are as follows:

Deg F	950	1000	1050	1100	1150	1200
Psi	8250	6250	4800	3700	2700	1950

* The term "operator" is used to designate the person having final control of any adjustments.

A.S.M.E. NEWS

And Notes on Other Engineering Societies

How A.S.M.E. Special Research Committees Served American Wartime Munitions Program

Three Reports Crystallize Ordnance "Know How"

HOW wartime employment of the research machinery of The American Society of Mechanical Engineers by the U. S. Army Ordnance Department created a body of experts who first studied existing shell-manufacturing practice, then guided it into channels suggested by laboratory research and finally crystallized the wealth of the American shell-producing "know how" into language easily understood by production men for quick reference in future emergencies, was recalled recently when the Executive Committee of the Council of the A.S.M E. discharged three Special Research Committees on (1) Forging of Steel Shells, (2) Demolition Bomb Bodies, and (3) Finishing and Machining of High-Explosive Steel Shells.

Over a period of six years, under several Ordnance contracts totaling $160,000, more than thirty members of the three committees aided by a full-time projects director, together with five field investigators, subjected 100 shell-producing plants to an intense critical analysis in search of the best shell-producing techniques. At the height of the war effort when demand for production and difficulties with materials were harassing manufacturers, most of whom had adapted existing facilities to production of shells, these A.S.M.E. research committees served as boards of authority before which technical problems of vital importance were presented for quick solution.

Working in the shops where problems could be studied as soon as they occurred, and relying on the laboratory facilities of the Case School of Applied Science (now the Case Institute of Technology) and the Westinghouse Research Laboratories, the Committee was able to concentrate a great fund of experience on isolated technical problems, or if new knowledge were required, to outline the problem or research program to provide specific data upon which a decision could be made.

Record munitions production during the first World War, with its tremendous industrial concentration on specific production problems provided a great deal of new knowledge and developed a fund of engineering and managerial skill. But, buried in tons of correspondence, the new knowledge was not analyzed or systematically recorded either during or following the war. When the need for munitions had been satisfied, the newly developed skill was diverted into new channels. As a consequence the knowledge was forgotten and the war skills were lost.

Three Reports Prepared

With this old lesson in mind the U. S. Army asked for, and the A.S.M.E. Research Committees produced, simple readable reports which reduced complex operations into logical operation-by-operation descriptions of shell production. The reports were unusual examples of packaged know-how. They are written from the point of view of the industrialist called upon to adapt his facilities to emergency production of shells, about which he is presumed to have little or no special knowledge. In some future emergency when the national fund of personal experience in shell production will be at low ebb, these reports will be "how-to-do-it" textbooks to thousands of engineers and industrialists who may be called upon to produce shells.

In a few hundred pages of logical exposition, the reports will reveal to the future shell producer what materials he will be called upon to use in his new operations, what facilities he will need, what plant layout he can use to best advantage and the essential information on each operation involved in shell production. In effect, the reports lay bare the basic technique at the stage to which it had been developed in World War II.

Planning Began in 1941

The research programs were first conceived in 1941 when the expanding program of American arms production began to slow down because of the lack of aids to manufacturers who were converting existing facilities and methods to an unfamiliar operation. To provide quick information at the points where it was needed, the Ordnance Department was envisaging an industry-wide research group who could conduct field studies of operations, determine best methods, and disseminate such information to discourage wasteful and inefficient plant operation.

Aware of the difficulties confronting shell manufacturers, the A.S.M.E. appointed a committee of specialists to study how the Society could help industry and to propose a procedure by which the national-arms program could be aided.

As soon as the A.S.M.E. Special Research Committee on Forging of Steel Shells was formed, it was recognized that the success of research activities centering in more than 100 plants scattered over the United States and Canada would depend on the co-operation and confidence of security conscious manufacturers.

Suggested Program

To effect this co-operation, the Committee discussed the following objectives with the industry:

(1) To build and operate a pilot shell plant on a commercial basis that would compare and evaluate directly all methods of shell making and factors such as tool designs, tool materials, billet forms, and deformation forces.

(2) To conduct field studies, supported by laboratory research and theoretical studies, coupled with a real collation of operating data on production, tool life, production costs, defects, rejections, and other manufacturing problems.

(3) To act as an information exchange among all shell forgers in the United States and Canada, in which not front-office reports but real operating details, improvements, and other practicable information would be continuously made available to all properly approved personnel.

Shell manufacturers, who were already up to their knees in production problems, heartily endorsed the second and third objective of the Committee, but discouraged the first because of the lateness of the hour.

First Assignment

On the basis of this endorsement by industry and encouraged by the successes of A.S.M.E. research machinery, the U.S. Army Ordnance Department approved financial support of the committee's proposed project. On April 25, 1942, a contract was signed and the work was on.

The committee, under the chairmanship of M. D. Stone, United Engineering and Foundry Company, Pittsburgh, Pa., engaged W. Trinks, consulting engineer, and a member of the committee, as a full-time projects director. Several other full-time field investigators were also engaged. To take advantage of Canadian experience in British shell program, the committee was expanded to include several Canadian specialists. Advisory members from the U. S. Army Ordnance Department and the U. S. Navy, Bureau of Ordnance, also joined the committee.

Members of the committee and the full-time investigators went into the field to study operations and gather data. As many as ten days were spent in each plant to prepare comprehensive reports on methods and problems. The work of the committee became so

well known among shell forgers, that in spite of suspicions aroused of security regulations, field workers received cordial reception and co-operation wherever they worked.

Program Saved Steel

With the advent of World War II, the U. S. Army Ordnance Department let out contracts for steel forgings whose specifications were based on experience of 1917–1918. Investigators were not long in the field when they realized that the advancement of the art between the wars had reached the stage where industry could meet the liberal contract specification even with the use of poor methods and old worn-out equipment. By suggesting improved techniques, the committee helped producers to turn out forgings of greater accuracy. This not only reduced time and steel lost in machining, but enabled the Ordnance Department to reduce tolerance specifications in subsequent contracts without jeopardizing vital production.

As the demands for steel increased and the availability of the 1340 free-machining high-sulphur high-manganese steel diminished, shell producers were called upon to use shell billets of WDSS-3 steel. While this transition was in progress, the committee was on hand to guide producers over the new obstacle of forging and heat-treating introduced by the unfamiliar material.

The work of the Research Committee on Forging of Steel Shells was well on its way when the war in Europe and the East began to place emphasis on demolition bombs. These bombs, carried by aircraft, were characterized by relatively large size and thin wall sections. They presented engineering problems and production operations different from those under investigation by the A.S.M.E. Research Committee on Forging of Steel Shells.

A.S.M.E. Studies Demolition Bombs

Encouraged by the results being achieved by use of A.S.M.E. research personnel and procedures, the Ordnance Department in September, 1943, entered into a second contract with the Society to conduct a parallel investigation of the engineering problems involved in making demolition bombs. Accordingly, the A.S.M.E. Research Committee on Demolition Bomb Bodies was organized. Dr. M. D. Stone agreed to take over the chairmanship. Composed of some members drafted from the original committee and several specialists in the fabrication of pressure vessels, the new project was able to progress rapidly.

In 1945, several months before the end of the war in the Pacific, A.S.M.E. machinery was called upon for the third time to crystallize ordnance know how required by the Ordnance Department to supplement the A.S.M.E. research reports on the forging of steel shells and the fabrication of demolition bodies. Broader in scope than the earlier contracts, the third Ordnance Department contract directed the Society to undertake a study to determine how best to make shells quickly which met ordnance specifications while utilizing existing machines and a minimum of man-hours.

To meet the new assignment, the Society organized the A.S.M.E. Research Committee on Finishing and Machining of High Explosive Steel Shells. D. W. Fletcher, National Tube Company, took over the chairmanship and the research work under the over-all direction of Professor Trinks. Some members were again drafted from the earlier committees and new specialists were called upon to serve. The committee broke down the successful production of shells into four departments: machines, tools, handling equipment, and plant layout. Twenty-six plants were visited before the end of the war began to slow down shell operations. To complete its report, however, the committee canvassed 22 other plants by a questionnaire.

Out of the critical analysis of the data thus obtained, the committee produced the third A.S.M.E. report to the Ordnance Department. This completed the trilogy of basic ordnance know-how, which represents one of the significant contributions of the organized engineering profession to a nation at war.

Fifteen Nations Ratify I.O.S. Constitution

THE International Organization for Standardization, set up provisionally at a meeting of 25 nations in London last October, has become the official body for international standardization work following ratification of its constitution and by-laws by the national standards bodies of 15 nations, Charles leMaistre, secretary in charge of the provisional office, announced recently.

The United States, which was the first country to ratify the convention setting up the new organization through approval of the board of directors of the American Standards Association, has now been joined by the following 14 countries: Chile, Brazil, Australia, Mexico, Finland, France, Switzerland, China, Austria, United Kingdom, Sweden, India, Czechoslovakia, Denmark.

Difficulties in securing office space at Geneva, Switzerland, which will be the headquarters of I.S.O. so far have been among the factors delaying the opening of an office.

A committee representing the United States, Great Britain, France, Belgium, Russia, and Brazil is surveying the field to secure a secretary general to take charge of the new permanent I.S.O. office which is expected to be in operation by early autumn. Final decision on the selection of the secretary general will rest with the I.S.O. council representing 11 nations, probably at a meeting at Geneva in June.

Nation Honors Engineers

PRESIDENTIAL Certificates of Merit were awarded to five engineers, who were organizers or members of the E.J.C. National Engineers Committee, "for outstanding fidelity and meritorious conduct in aid of the war effort against the common enemies of the United States and its Allies in World War II." The specific services rendered were the E.J.C. reports on the industrial disarmament of Germany and Japan.

The awards were presented by Gen. Courtney H. Hodges, First Army Commander at Governors Island, New York, N. Y., April 14, 1947.

Engineers honored were: Sidney Dale Kirkpatrick, for his services as a member of the National Engineers Committee; Carlton Springer Proctor, for services in connection with the formation and organization of the committee; Harry Stanley Rogers, for services as member of the Committee; Medley Gordon Brittain Whelpley, for services as chairman of the task committee on the chemical industry of the National Engineers Committee; Robert Earl McConnell, for services as chairman of the National Engineers Committee; and Malcolm Pirnie, for services as chairman of the executive committee of the E.J.C. which organized the National Engineers Committee.

ENGINEERS WHO WERE HONORED FOR E.J.C. REPORTS ON INDUSTRIAL DISARMAMENT OF GERMANY AND JAPAN

(*Left to right:* Malcolm Pirnie, Carlton S. Proctor, Robert E. McConnell, Medley G. B. Whelpley, H. S. Rogers, and S. D. Kirkpatrick.)

Results of A.S.M.E. Opinion Poll on Labor Legislation

IN REPLY to President E. W. O'Brien's questionnaire sent to members of the A.S.M.E. with his letter of March 31, 1947, more than 10,000 members expressed themselves on questions of how professional employees should be provided for in any new labor legislation.

The A.S.M.E. is one of six engineering societies participating in the Engineering Societies Labor Legislation Panel in an effort to secure labor legislation which would, (1) give professional employees freedom of choice in accepting or rejecting collective bargaining; (2) prevent the arbitrary inclusion of engineers in unions with nonprofessional employees; and (3) permit professional employees to organize their own bargaining units if they so desire.

When these points were suggested to congressional legislators at recent hearings, several Congressmen expressed the view that they would be more sympathetic to the program if the Panel had asked to remove entirely all professional employees from the provisions of any labor legislation.

In the light of this development, President O'Brien mailed the questionnaire to provide William F. Ryan, Fellow A.S.M.E., the Society's representative on the Panel, with accurate information about the wishes of A.S.M.E. members to guide him at future congressional hearings.

The questionnaire contained two main questions:

(1) Do you favor or do you not favor inclusion of professional employees under a labor law with the safeguards proposed by the Labor Legislation Panel?

(2) Do you favor or do you not favor exempting professional employees from the provision of any national labor act?

Several other questions sought information of the function, membership status, and age of members who answered returns.

After tabulation and analysis of returns, the following statement was prepared by Mr. Ryan:

"Question (1) on the ballot was asked to determine to what extent the membership favored the amendments proposed by the Panel.

"Question (2) was asked to determine what proportion of our membership would favor the more sweeping provisions apparently favored by the House Committee.

The results of the poll are shown in Table 1 and Table 2.

The vote on question (1) shows that a majority of the membership do not favor inclusion of professional employees under a national labor law, even with the safeguards proposed by the Panel. However, the vote on this question also shows that the younger and nonsupervisory members very definitely do favor the right to bargain collectively, provided it can be done in professional units as proposed by the Panel.

The vote on question (2) shows that a larger majority are not in favor of collective bargaining by engineers under any circumstances, and would prefer complete exclusion of professional employees from any national labor act. Even the younger members and the nonsupervisory members are in favor of such exclusion, although by a lower majority than the supervisory members and consultants.

At first sight it may appear that a majority in favor of both questions is contradictory. We interpret it, however, to mean that a large majority of our members of all ages and positions would favor exclusion of professional employees from legal provisions for collective bargaining, but that if any provision is made for collective bargaining, then professional employees shall have the safeguards proposed by the Panel, namely, to refrain from collective bargaining if they choose; or if they wish to bargain, then they should have the right to do so as an exclusively professional unit. Neither of these privileges is provided by the present law. A 'yes' vote on either question indicates the desire for some change in the present law. Only the negligible number, 161 out of 10,245, who voted 'no' to both questions can be assumed to favor the status quo.

The conclusions drawn from this opinion poll are therefore as follows:

(1) The membership is overwhelmingly against the present national labor relations act as it affects professional employees.

(2) Approximately 75 per cent of our total membership would favor complete exclusion of professional employees from national legislation, but that a substantial minority, particularly of younger men, prefer to retain the right to bargain collectively, provided it can be done at their own choice and in their own manner.

Your representative on the Legislative Panel will be guided by these implications of the poll."

TABLE 1 ANALYSIS OF REPLIES TO QUESTIONS 1 AND 2

	Supervision		Consultants		Non-supervision		Supervision not recorded		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Those in favor of inclusion of engineers in any new law but with specific safeguards	1477	37	481	34	2612	60	76	33	4646	46
Those not in favor of this provision	2530	63	923	66	1740	40	153	67	5346	54
Number who answered question	4007	100	1404	100	4352	100	229	100	9992	100
Those in favor of exempting engineers from provisions of any new law	3499	83	1239	84	2839	66	193	83	7770	76
Those not in favor of this provision	715	17	236	16	1485	34	39	17	2475	24
Number who answered question	4214	100	1475	100	4324	100	232	100	10245	100

TABLE 2 ANALYSIS OF THE RETURNS FROM NONSUPERVISORY PERSONNEL BY AGE GROUPS

	Under 26		26–35		36–45		Over 45		Not recorded		Total
	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Those in favor of inclusion of engineers in any new law but with specific safeguards	587	70	1467	64	287	47	252	41	19	80	2612
Those not in favor of this provision	248	30	804	36	318	53	365	59	5	20	1740
Number who answered question	835	100	2271	100	605	100	617	100	24	100	4352
Those in favor of exempting engineers from provisions of any new law	503	62	1373	61	451	73	500	80	12	53	2839
Those not in favor of this provision	310	38	867	39	166	27	131	20	11	47	1485
Number who answered question	813	100	2240	100	617	100	631	100	23	100	4324

Engineers Day Proclaimed in Georgia

THE engineering profession, the engineers of the State of Georgia, and the Georgia School of Technology were honored in a proclamation issued by Acting Governor M. E. Thompson in which he set aside May 17, 1947, as "Engineers Day" and invited the people of Georgia to view the exhibits and demonstrations staged on the campus of the state's only engineering institution in celebration of the 62nd year of its founding.

Engineers Needed in Naval Reserve

THE United States Navy is calling upon engineers to support the new Naval Reserve program. Young men are needed between the ages of 17 to 39, inclusive, to learn and preserve skills developed during the war.

Because mechanized warfare depends on the entire range of mechanical trades and skills, education is the keystone of the program. Engineers can aid by enrolling. Older engineers can aid by encouraging young men to take advantage of the opportunity offered.

First-line planes, submarines of the advanced types, and facilities of Navy shore stations are available for training purposes.

E.C.P.D. Publishes Credo for the Engineer

SO ENGINEERS may display a statement of the principles by which they work, the Engineers' Council for Professional Development has published the engineer's credo, "Faith of the Engineer," in a form suitable for framing.

Whether he serves the public from a plush Manhattan office, or a partitioned corner of a noisy plant, or a crude construction shack, the engineer can inspire confidence and win respect for his profession by demonstrating a faith in the principles of his profession.

The E.C.P.D. credo, shown on this page, is already familiar to engineers, but not so familiar to the general public. It is now available in a 15½ × 22 in. size on high-quality paper. The credo is printed in black except for the E.C.P.D. monogram in the top center and the first sentence "I AM AN ENGINEER," which is printed in red. It is an attractive document reflecting the dignity and pride with which engineers regard their profession.

Large enough to be read comfortably from a distance of 10 ft, the credo deserves to be hung in full view in office, shop, and shack where an engineer is at work so that every client, employer, labor leader, shop steward, and man at the bench and machine may learn to know the motivating structure of the profession. Only then will the "Faith of the Engineer" take its place among the great credoes of the professions.

The credo will soon be available in an 8½ × 11-in size. The large size sells for $3. The small size will sell for $0.50. Copies may be ordered from the E.C.P.D., 29 West 39th Street, New York 18, N. Y.

A.I.E.E. Considers Plans for Organization of Profession

A PRELIMINARY report of a survey of members of the American Institute of Electrical Engineers indicates that approximately 40 per cent of electrical engineers who expressed opinions and preferences on organization of the engineering profession would like to see an over-all American Society of Engineers into which would be incorporated all existing societies and which would function in all the fields of technical and professional activities involving engineers.

A survey was started two years ago to determine what electrical engineers consider to be the type of organization of the engineering profession which would best perform the following functions: (1) disseminate technical information; (2) provide greater service to society; (3) maintain high professional standards; (4) and enhance public esteem and recognition of engineers.

Four likely plans of organization were devised and worked up on display placards. At all types of meetings of Institute members in many sections of the country, the cards were displayed and the problem of engineering organization discussed. Members were then asked to fill out questionnaires which registered their opinions and preferences.

Four plans were discussed as follows:

Plan A. This plan proposed consolidation of all existing electrical-engineering societies only into a new American Association of Electrical Engineers.

Plan B. This plan proposed a new Engineering Professional Society which would function independently of all existing engineering societies. The new body would limit its interest to questions of general professional interest common to all engineers and leave to existing societies complete autonomy in their particular field of engineering.

Plan C. This plan is similar to Plan *B* except it proposed an engineering federation or council composed of representatives of existing societies rather than another society to handle common professional questions.

Plan D. This plan proposes a new American Society of Engineers in which all existing engineering societies would be incorporated.

A preliminary analysis of 1450 returns shows that while Plan D received most votes, no plan received a majority of votes cast. In order of preference, Plan D came first with approximately 40 per cent of the votes; Plan C came second with 26 per cent; Plan B third with 20 per cent and Plan A fourth with 4 per cent. About one per cent voted for no change in the present organization of the Institute.

A complete report on the survey is still in the process of preparation. It is expected to incorporate many suggestions contributed by Institute members.

FAITH OF THE ENGINEER

I AM AN ENGINEER. In my profession I take deep pride, but without vainglory; to it I owe solemn obligations that I am eager to fulfill.

As an Engineer, I will participate in none but honest enterprise. To him that has engaged my services, as employer or client, I will give the utmost of performance and fidelity.

When needed, my skill and knowledge shall be given without reservation for the public good. From special capacity springs the obligation to use it well in the service of humanity; and I accept the challenge that this implies.

Jealous of the high repute of my calling, I will strive to protect the interests and the good name of any engineer that I know to be deserving; but I will not shrink, should duty dictate, from disclosing the truth regarding anyone that, by unscrupulous act, has shown himself unworthy of the profession.

Since the Age of Stone, human progress has been conditioned by the genius of my professional forbears. By them have been rendered usable to mankind Nature's vast resources of material and energy. By them have been vitalized and turned to practical account the principles of science and the revelations of technology. Except for this heritage of accumulated experience, my efforts would be feeble. I dedicate myself to the dissemination of engineering knowledge, and, especially, to the instruction of younger members of my profession in all its arts and traditions.

To my fellows I pledge, in the same full measure I ask of them, integrity and fair dealing, tolerance and respect, and devotion to the standards and the dignity of our profession; with the consciousness, always, that our special expertness carries with it the obligation to serve humanity with complete sincerity.

Published by
Engineers Council for Professional Development

A.S.M.E. 1947 Fall Meeting to Be No Ordinary Meeting

IF 1947 were an ordinary year, the A.S.M.E. 1947 Fall Meeting to be held in Salt Lake City, Utah, Sept. 1 to 4, 1947, might be expected to be an ordinary engineering meeting which happened to be planned for an extraordinary city situated in the heart of a natural wonderland of mountains and canyons.

But 1947 is not an ordinary year. It is the centenary year of the founding of Salt Lake City. It is the year that will tell and retell the dramatic story of Brigham Young and his band of pioneers who transformed the desert into a magnificent garden. It is the year of festive hospitality, of celebration, in a city already famous for its good and amiable living.

The A.S.M.E. is fortunate in its opportunity to participate in this pageant of America, to do its part in calling attention to the industrial contribution of the people of Utah.

Salt Lake City in its history and its architecture reflects the accomplishment of great things. On July 24, 1847, the city was founded by Mormons seeking sanctuary from a world unfriendly to their faith. Headed by Brigham Young, they entered Salt Lake Valley by way of Emigration Canyon. "This is the place," he said, and here the band pitched camp, and here out of the barren, parched desert, inhabited only by jackrabbits, rose a magnificent city. This is no legend from the dawn of man's intelligence but a record of yesterday.

Members who plan to participate in the A.S.M.E. 1947 National Parks Tour or the A.S.M.E. 1947 Fall Meeting, will be able to witness for themselves the inspiring valley of the Great Salt Lake, and the grandeur of its mountains and canyons. On every hand they will see evidence of the foresight of men who planned for tomorrow "better than they knew."

Of particular interest will be the Salt Lake itself, in whose salt-laden waters human beings float like corks. Then there will be the ten-acre Temple Square with its Mormon Church and the estates of Brigham Young. In the Capitol Building, itself a noteworthy specimen of American architecture, will be found an exhibit of pioneer relics and displays of the mineral and agricultural wealth of Utah.

Of engineering interest will be the Utah Copper Mine in Bingham, a few miles from Salt Lake City. Built in the bottom of a canyon, it is a town one street wide and three miles long, over which huge electric shovels on a score of terraces dig away at a mountain of copper ore.

As one part of the centenary celebration of the founding of Salt Lake City, the A.S.M.E. 1947 Fall Meeting will not be an ordinary meeting.

UTAH COPPER MINE AT BINGHAM, UTAH, 28 MILES SOUTHWEST OF SALT LAKE CITY WHERE THE A.S.M.E. 1947 FALL MEETING WILL BE HELD

Engineers in Congress Honored

ENGINEERS in Congress were honored at a dinner held at the Willard Hotel, Washington, D. C., April 24, 1947. The dinner was sponsored by the District of Columbia Council of Engineers and Architects and was attended by more than 100 engineers.

Honored guests were: Congressmen Gordon L. McDonough and Carl Henshaw of California, and Congressmen Frederick A. Muhlenberg and Paul B. Dague of Pennsylvania.

In talks following the dinner, the speakers commented on the need for engineers in Congress.

Research on Coal-Mining Methods Proposed

THE bituminous-coal industry is making plans for "conducting research into new mining methods," with a view to reducing production costs. This announcement was made during a special meeting held recently in Pittsburgh, Pa., under the auspices of Bituminous Coal Research, Inc., national research agency of the industry.

A large group of coal-land and railroad-company executives attended the meeting called to consider "ways and means for rapid advancement of mining machines and methods to reduce the cost of coal production."

The program contemplates raising a special fund to finance a new research activity of the industry, naming a Mining Development Committee of top-level executives representing the sponsors, and consulting with mining-machinery companies as the development plans are being formulated.

Invitations to participate in this proposed program have been extended to all commercial and captive coal-operating companies in the United States, all coal-land companies, and the railroads handling bituminous-coal traffic.

A.S.M.E. Calendar

of Coming Events

June 12–13, 1947
A.S.M.E. Wood Industries Division Meeting
Madison, Wis.

June 16–19, 1947
A.S.M.E. Semi-Annual Meeting
Chicago, Ill.

June 23–25, 1947
A.S.M.E. Applied Mechanics Division Meeting
Schenectady, N. Y.

Sept. 1–4, 1947
A.S.M.E. Fall Meeting
Salt Lake City, Utah

Sept. 8–9, 1947
A.S.M.E. Instruments and Regulators Division Meeting
Chicago, Ill.

Oct. 6–8, 1947
Petroleum Committee of the A.S.M.E. Process Industries Division Meeting
Houston, Texas

Oct. 20–22, 1947
A.S.M.E. Fuels Division Meeting
Cincinnati, Ohio

Dec. 1–5, 1947
A.S.M.E. Annual Meeting
Atlantic City, N. J.

March 1–5, 1948
A.S.M.E. Spring Meeting
New Orleans, La.

June, 1948
A.S.M.E. Semi-Annual Meeting
Milwaukee, Wis.

Sept., 1948
A.S.M.E. Fall Meeting
Portland, Ore.

Consulting Manual Under Revision

THE A.S.M.E. "Manual of Consulting Practice for Mechanical Engineers" is in process of revision by a committee composed of the following: S. Logan Kerr, member A.S.M.E., president, S. Logan Kerr and Company, Philadelphia, Pa.; Albert C. Wood, fellow A.S.M.E., consulting engineer, Albert C. Wood and Associates, Philadelphia, Pa.; and J. Harland Billings, member A.S.M.E., professor of mechanical engineering, Drexel Institute of Technology, Philadelphia, Pa.

The committee will welcome comments and suggestions from members bearing on the present manual as an aid in the work of revision.

It is planned to have the revised text available for review before the end of the year.

Communications should be addressed to S. Logan Kerr, Bankers Securities Building, Philadelphia 7, Pa.

Last Notes on A.S.M.E. 1947 Semi-Annual Meeting

Early Arrival Urged

PLAN to arrive on Sunday, June 15, to participate in the tour of Chicago and the dinner at the Michigan Shores Club as guests of the A.S.M.E. Chicago Section.

Discussion From the Floor

Come prepared to express your ideas on the subject of the engineer's responsibility in public affairs. The Public Affairs Committee Luncheon on Tuesday, June 17, will conclude as an open forum, at which you may express your ideas before a truly national audience of engineers.

Inspection Trips

If you wish to visit any industrial plant and point of interest in Chicago, write to Vernon Leach, chairman, Registration Committee, 400 West Madison St., Chicago, Ill., and the A.S.M.E. Chicago Section will make the necessary arrangement for the visit. State the plant you wish to visit, and the day and time you prefer to make the visit. The Committee will do the remainder.

Music and the Banquet

At the banquet on Wednesday, June 18, you will be entertained by The Alice Stephens Singers, a group of 40 "white collar" girls and by the Stephenairs, a male octette. Between the songs, Leo Terry will play the Hammond organ. Following dinner ceremonies, there will be dancing and entertainment by the Johnny Jones Orchestra.

New A.S.M.E. Publications Announced

FOUR new American standards, sponsored by the A.S.M.E., and a pamphlet on the application of coal-burning equipment have been published by the Society and are now available for distribution.

Involute Splines, Side Bearing (B5.15—1946). This is one of a series of standards developed by the A.S.A. Sectional Committee on the Standardization of Small Tools and Machine Tool Elements under the sponsorship of The American Society of Mechanical Engineers, National Machine Tool Builders Association, and the Society of Automotive Engineers.

This is a revised edition of a standard originally issued in 1939. It represents a considerable advance in the manufacture of involute splines. The range covered by the 59-page standard is from 1/2 (two/one) diametral pitch and from 6 to 50 teeth. The price per copy is $1.

Steel Socket-Welding Fittings (B16.11—1946). This new standard is the work of the A.S.A. Sectional Committee on the Standardization of Pipe Flanges and Fittings B16 sponsored by the A.S.M.E., Heating, Piping, and Air Conditioning Contractors National Association, and the Manufacturers Standardization Society of the Valves and Fittings Industry. The standard covers dimensions, finish, tolerances, testing, marking, and minimum requirements for fittings for nominal pipe sizes from 1/8 to 3 in. While it is written specifically for wrought carbon and alloy steel fittings, it is recommended for fittings made of other materials. Price per copy is $0.60.

Brass or Bronze Screwed Fittings, 125 lb (B16-15—1947). This new standard covers design data for fittings for nominal pipe sizes from 1/8 to 4 in. Cost per copy is $0.65.

Drawings and Drafting Room Practice (Z14.1—1946). Originally published in 1935, this standard has been under revision since 1940. It covers arrangement of views, lines, and line work, sectional views, screw-thread representation, dimensioning, notes, trimmed sizes of drawing paper and cloth, also titles and lettering. It sells for $1.25.

Improved Application of Coal-Burning Equipment. During the 1946 Annual Meeting the A.S.M.E. Power and Fuels Divisions sponsored a joint session during which eight engineers representing coal-burning-equipment manufacturers and research organizations spoke on recent advances in coal-burning technology. The papers have been assembled and issued in a pamphlet "Improved Application of Coal Burning Equipment." The papers cover a study of recent boiler installations, fuel economics affecting boiler-unit design, and lessons learned in burning coal during the war years. Others treat such matters as designing coal-burning equipment to eliminate trouble spots, application of combustion equipment to medium and small industrial plants. Price of the pamphlet is $0.75.

A.S.M.E. publications can be obtained at A.S.M.E., Sales Department, 29 West 39th Street, New York 18, N. Y.

New Metering Code Available

AS the result of five years of intensive work on the part of the A.S.M.E. Special Research Committee on Fluid Meters and the American Petroleum Institute's Topical Committee on Pipe-Line Technology, mechanical engineers working with liquid-petroleum products now have available a long-needed handbook of modern practices in the installation, proving, and maintenance of positive-displacement meters as well as a guide for the training of personnel in the handling of such meters.

A new 36-page code has recently been issued that can serve as a suitable basis of reference in contracts for the purchase, sale, or exchange of petroleum and its products, at bulk plants, loading racks, and from tank trucks.

The code describes techniques which have been proved practical for the metering of petroleum oils differing in volatility and viscosity from "liquefied petroleum gases" with Reid vapor pressures as high as 400 lb through a wide range of "refined products and fuels" to any reasonably fluid "crude oil" that is free or can be freed of abrasive foreign matter and wax. The techniques are applicable to any of the normally recognized five classes of positive-displacement meters or their combinations.

Based on a wide field of experience and much research, this code harmonizes the views of all concerned, so that it is completely unbiased and objective in context. The text has been thoroughly reviewed and edited to make it easily readable as well as practical.

Issued under its short title "Petroleum PD Meter Code" and its full title "Tentative A.S.M.E.-A.P.I. Code for the Installation, Proving, and Operation of Positive-Displacement Meters in Liquid Hydrocarbon Service," the code contains 14 diagrams and three charts and suggested forms. It sells for $1 per copy and may be obtained from the A.S.M.E., Sales Department, 29 West 39th St., New York 18, N. Y.

E.J.C. for Maryland Achieves Success

ACTION by engineers of Maryland in preparing recommendations for revision of the Maryland Registration Act of Professional Engineers and Land Surveyors has resulted in a new bill recently passed by both houses of the Maryland Legislature. The new law corrects omissions and ambiguities in the original act and represents a major step forward for professional engineering in the state.

Joint action by Maryland engineers was made possible by organization in January, 1947, of the Engineers Joint Council for Maryland composed of the local sections of the A.S.C.E., A.S.M.E., A.I.E.E., and A.I.Ch.E.

E. B. Whitman, member A.S.M.E., consulting engineer, Whitman, Requardt, and Associates, Baltimore, Md., represents the A.S.M.E. on the Council. A. L. Penniman, general superintendent, Electric Light and Power Company of Baltimore, Baltimore, Md. is first alternate and H. W. Woodward, chairman, A.S.M.E. Baltimore Section, is second alternate. Other members are: P. L. Holland, A.S.C.E.; B. Van Ness, Jr., A.I.E.E.; and E. W. Guernsey, A.I.Ch.E.

The objectives of the E.J.C. for Maryland are: (1) To develop greater confidence in, and respect for, the engineering profession; (2) to provide sound bases for such confidence and respect; (3) to make available for the common good of society the full resources of the profession; (4) to promote and enhance the economic and social status of engineers by means of all available ethical professional methods.

Correction

In the account of the centenary celebrations of the Institution of Mechanical Engineers in the May issue of MECHANICAL ENGINEERING, Paul W. Kiefer was erroneously listed as a member of the A.S.M.E. Mr. Kiefer is a Fellow of the Society.

ALVIN E. DODD, 1947 GANTT MEDALIST

Alvin E. Dodd to Receive Gantt Medal

ALVIN E. DODD, member A.S.M.E., and president of the American Management Association, has been awarded the 1947 Gantt Medal, it has been announced by the Gantt Medal Board of Award of the Institute of Management and The American Society of Mechanical Engineers.

Mr. Dodd is a graduate of the Armour Institute of Technology, Chicago, Ill. As teacher, business executive, and full-time president of the American Management Association, he has influenced the thinking of American industry by his teaching of the scientific approach to problems of management in administration, finance, distribution, sales, and personnel relations.

The Gantt Medal was established in 1929 to memorialize the achievements and service to the community rendered by Henry Laurence Gantt, member A.S.M.E., management and industrial engineer. The medal is conferred in recognition of "distinguished achievement in industrial management as a service to the community."

Engineering Studies Liberalized

LEHIGH University, Bethlehem, Pa., in response to the changing needs of industry, is liberalizing its engineering curricula by including three hours each semester during the junior and senior years, for general study courses in history, economics, literature, philosophy, the fine arts, and music. The changes follow a report by the Educational Policy Committee of the faculty.

Civilians Appointed to Aid U. S. Defense Plan

AN advisory group of six civilian scientists and engineers has recently been appointed to work with the policy committee of the new Joint Research and Development Board and to perform the unusual function of counseling the Army and Navy on strategic decisions.

The advisory group consists of the following: I. I. Rabi, professor, 1944 Nobel Prize winner in physics, Pupin Laboratory, Columbia University; Alfred L. Loomis, New York, N. Y.; Caryl P. Haskins, Haskins Laboratories, New York, N. Y.; Luis W. Alvarez, professor of physics, University of California; William B. Shockley, Bell Telephone Laboratories, Summit, N. J.; and George F. Doriot, Harvard Business Administration School.

The Joint Research and Development Board was created by the Secretaries of the War and Navy. The board has authority to make final decisions in co-ordinating research; in telling the Army and Navy which should act for both in certain fields to prevent duplications, and in suggesting fields for activity which it believes are being slighted or overlooked.

The Board, headed by Dr. Vannevar Bush, is one of the most thorough experiments in voluntary unification attempted by the Armed Forces. While Dr. Bush is optimistic over prospects for the J.R.D.B., he is an ardent supporter of the Army-Navy-Air Force merger and has declared that the board by no means supplants the need for unification.

Dr. Bush is hopeful that the Congress will enact an all-science foundation law which will put scientific training back under civilian auspices.

New York Technical Council Incorporated

THE Technical Societies Council of New York, Inc., composed of 14 engineering and technical societies in the New York metropolitan area, was formally incorporated under the laws of the State of New York on April 7, 1947.

Organized during the early days of the war at the request of Donald M. Nelson, the Council disbanded after V-J day, but when the need for a co-ordinating body in New York persisted, it was reorganized on July 16, 1946. Its main function is to co-ordinate the activities of member societies.

H. C. R. Carlson, member A.S.M.E., is president. Each member Society is represented by two delegates. R. W. Flynn, member A.S.M.E., is the other A.S.M.E. representative on the Council.

E.J.C. Publishes Bulletin for Latin America

THE E.J.C. Committee on International Relations through its Commission for Latin America has arranged to make technical literature published in the United States available to engineers in the Latin-American countries through a 96-page bulletin, each issue of which will contain about 30 slightly condensed articles selected from the journals of five constituent societies of the E.J.C.

The first issue, prepared for release in May, 1947, is to be mailed to 1500 engineers in South and Central America. The bulletin is called *Adelantos de Ingenieria*.

Financial support for the first four issues of the bulletin has been provided by the State Department from left-over funds originally appropriated for development of cultural relations with Latin America. If the bulletin is favorably received and proves useful, other sources of financial support may be sought to continue the project for another year.

Articles chosen for their usefulness to South American industry will be condensed slightly, reproduced by the photo-offset process, and bound in the bulletin. Except for the editorial comment in Spanish and Portuguese, the articles will be reproduced in English just as they appear in the engineering journals.

W. W. Nichols Honored

AT THE annual dinner of the Yale Engineering Association, held at the Yale Club, New York, N. Y., on April 25, William Wallace Nichols, member A.S.M.E., and for many years assistant to the chairman of the board of the Allis-Chalmers Manufacturing Company, received the Y.E.A. Award for Meritorious Service to Yale University. The citation on the certificate of award reads:

"Instructor in mechanical engineering at Yale from 1894 to 1900; pioneer in the electrical manufacturing industry; pioneer in industrial relations, pioneer in the exchange of experience in administrative problems by top executives; distinguished for his service to the nation as chairman of industrial commissions to France and Mexico, to American trade and industrial enterprises as member and officer of many trade associations, and to education at the college and apprentice levels. This award is granted in recognition and appreciation of services to Yale University and to the Yale Engineering Association, of which he is a Charter Member."

The Y.E.A. Award for the Advancement of Basic and Applied Science was bestowed upon F. W. Godsey, Jr., manager, New Products Division, Westinghouse Electric Corporation.

Technical Books Compose One Third of Shipments by A.B.C.

BOOKS on engineering, technology, and science represented 33 per cent of the volumes shipped to war damaged libraries in 34 countries of the world since March, 1946, according to the American Book Center for War Devastated Libraries, whose report on the first year of operation was recently issued to contributors.

After careful appraisal of contributions received from 950 institutions and 2800 individuals, a staff of 30 persons assembled and packed 5000 cases—an equivalent of 50 freight-car loads—for overseas shipment. In all

720,000 volumes of books, periodicals, and pamphlets, each judged to be of lasting usefulness or needed immediately in reconstruction, were consigned to war-damaged areas where the need was greatest. Another 200,000 volumes are being prepared for immediate shipment.

The American Book Center was created at the end of World War II to perform the work of assembling, sorting, allocating, and packing for overseas shipment books and printed matter urgently needed by engineers and scholars abroad who were faced with the task of reconstruction.

In response to an appeal from the Joint Committee on Books for Devastated Libraries composed of 12 American and Canadian national library associations, American commercial firms, labor organizations, and scores of agencies, contributed a fund of $100,000 to finance the organization of a working force. As its part, the Library of Congress provided quarters of the Center comprising 12,000 sq ft of floor space and bookstacks with 8000 feet of shelf space. First shipments were made in March, 1946.

The American Book Project won the immediate support of American professional and scientific societies. Assuming responsibility for soliciting books on engineering and science, the Engineers Joint Council, through its Committee on International Relations, appealed to members of its constituent societies for books and funds for purchase of new books. A special bookplate was designed to mark contributions of American engineers.

Clarke F. Freeman, member A.S.M.E., in one of the largest contributions, offered 19 cases of books and documents which were consigned to the Nanking Library of the National Resources Commission of China. Other members offered bound copies of society publications. Following a recent letter to members by President E. W. O'Brien, contributions were increased by 20 per cent.

According to the A.B.C. report the need for books which are basic to reconstruction continues. Many requests from foreign libraries have not been met. Engineers who have books to contribute are urged to request shipping instructions from the Committee on International Relations, 29 West 39th Street, New York 18, N. Y.

Symposium to Be Held on Fluid Mechanics

A symposium on Fluid Mechanics, composed of seminars and lectures and intended for advanced students, engineers, and teachers, will be conducted at the University of Michigan, Ann Arbor, Mich., June 23 to August 16, 1947.

Among the lecturers will be: Theodore von Kármán, member A.S.M.E.; B. A. Bakhmeteff, member A.S.M.E.; Hugh L. Dryden, member A.S.M.E.; L. G. Straub, member A.S.M.E.; and others.

American Participation in Stockholm Management Congress Urged

The Eighth International Management Congress to be held in Stockholm, Sweden, July 3 to 9, 1947, provides American industry with an opportunity "to show businessmen of Europe that the competitive system of free enterprise is still the most efficient devised by man," according to William L. Batt, past-president and honorary member A.S.M.E., who as chairman of the International Committee of Scientific Management, will head the United States delegation of 200 industrial, government, labor, and agricultural leaders to the Congress.

In a statement urging American participation Mr. Batt said, "The Management Congress provides America with a unique and timely chance to give personal testimony to the superiority of dynamic, disciplined, and responsible American capitalism over socialism, statism, and all the other forces of controlled economy now conspiring against Europe's industrial freedom."

United States participation in the Eighth International Management Congress is being sponsored by the National Management Council of which John A. Willard, member A.S.M.E. is chairman.

The A.S.M.E. is a member body of the National Management Council which is an affiliate of the International Committee of scientific management.

Meetings of Other Societies

June 9–11
The American Society of Refrigerating Engineers, 34th spring meeting, Hotel Alexandria, Los Angeles, Calif.

June 9–13
American Institute of Electrical Engineers, summer meeting, Mount Royal Hotel, Montreal, Que., Can.

June 11–12
American Management Association, general management meeting, Hotel Pennsylvania, New York, N. Y.

June 15–18
American Boiler Manufacturers Association and Affiliated Industries, 59th annual meeting, French Lick Springs Hotel, French Lick, Ind.

June 16–19
National District Heating Association, 39th annual meeting, Hotel Ambassador, Atlantic City, N. J.

June 16–20
American Society for Testing Materials, 50th annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

June 18–21
American Society for Engineering Education, Minneapolis, Minn.

June 22–25
American Society of Agricultural Engineers, annual meeting, Benjamin Franklin Hotel, Philadelphia, Pa.

July 16–18
American Society of Civil Engineers, annual convention, Hotel Duluth, Duluth, Minn.

July 21–25
American Water Works Association, annual conference, San Francisco, Calif. (Number of hotels co-operating)

Actions of the A.S.M.E. Executive Committee

At a Meeting Held at Headquarters, April 18, 1947

A MEETING of the Executive Committee of the Council was held in the rooms of the Society, April 18, 1947. There were present: Eugene W. O'Brien, chairman; J. N. Landis, vice-chairman; F. S. Blackall, Jr., A. C. Chick, A. R. Mumford, K. W. Jappe, treasurer; and C. E. Davies, secretary.

A.S.E.E.-A.S.M.E. Summer School

Upon recommendation of the Finance Committee, a small contribution was voted in support of the summer school for mechanical-engineering teachers sponsored jointly by the American Society for Engineering Education and the A.S.M.E.

Questionnaires

The following policy on questionnaires to members was approved: All questionnaires dealing with national problems should be submitted to the Council or a qualified group concerned with the problem at issue for approval before mailing to members.

Exhibit of Goddard Rockets

It was noted that the Guggenheim Foundation for Aeronautics had offered to finance an exhibit of original Goddard rockets in the lobby of the Engineering Societies Building. When the exhibit had been proposed by the American Rocket Society, the Committee agreed to provide staff work and joint sponsorship, if financial support could be found.

Book Loans to Students

Upon recommendation of the Engineering Societies Library, it was agreed to rescind the

rule which requires student members to secure book loans through honorary chairmen of student branches. A.S.M.E. practice as a result now conforms with practice of other Founder Societies.

Appointments

The following appointments were approved:

Subcommittee on Materials of the Boiler Code Committee: C. A. Adams, chairman. Subgroup on Ferritic Plates and Tubular-Products Plates: C. H. Davidson, W. P. Gerhart, L. P. McAllister, A. C. Weigel, C. W. Wheatley.

Tubular Products: J. S. Adelson, Sabin Crocker, R. W. Emerson, T. G. Stitt, A. B. Wilder.

Subgroup on Ferritic Castings: W. F. Hess, J. W. Bolton, M. V. Healey, J. W. Juppenlatz, J. J. Kanter, J. S. Vanick.

Subgroup on Ferritic Forgings and Miscellaneous Ferritic Castings: J. S. Worth, F. W. Davis, L. W. Heise, D. B. Rossheim, A. O. Schaefer, F. S. G. Williams, E. J. Wiseman.

Subgroup on Austenitic Plates, Tubular Products, Castings and Forgings: S. K. Varnes, R. H. Aborn, P. R. Cassidy, E. C. Chapman, D. B. Rossheim, G. A. Sands.

Subgroup on Nonferrous Materials: F. W. Davis, C. L. Bulow, W. F. Burchfield, G. C. Holder, Merril Scheil, R. L. Templin.

Subgroup on Stress Allowances for Ferrous Materials: E. C. Chapman, A. B. Bagsar, L. D. Burritt, C. L. Clark, M. B. Higgins, A. Hurtgen, J. J. Kanter, R. K. Kulp, V. T. Malcolm, R. F. Miller, N. L. Mochel, M. S. Northrup, E. L. Robinson, D. B. Rossheim, J. W. Sands, A. P. Spooner, S. K. Varnes, A. E. White, J. G. Althouse.

Subgroup on Stress Allowances for Nonferrous Materials: H. B. Oatley, W. F. Burchfield, H. L. Burghoff, F. W. Davis, J. R. Freeman, Jr., W. P. Kliment, R. L. Templin.

Special Research Committee on Screw Thread Strength: George S. Case, Wm. C. Stewart, Paul DesJardins, and L. B. Tuckerman.

A.S.M.E. Representative on the Council of The Engineering Institute of Canada: Chester B. Hamilton, Jr.

A.S.M.E. 1947 Parks Tour

IF YOU have never been to Salt Lake City, Utah, now is the time to sign up for the A.S.M.E. National Parks Tour and become one of the participants at the "Utah Centennial Celebration—One Hundred Years of Progress—1847–1947," which coincides with the A.S.M.E. 1947 Fall Meeting, Sept. 1 to 4, 1947.

The A.S.M.E. tour, restricted to A.S.M.E. members, priced for no profit, is the trip of the year. It offers four weeks of memorable experiences, the inspiration of panoramic grandeur the comforts of excellent trains and hotel accommodations, the pleasures of good food and service, the stimulus of A.S.M.E. fellowship, and above all, the once-in-a-century opportunity to be part of the festivities of a memorable American event. Do not miss it.

Why is the Tour exceptional? It is restricted to 150 participants. It has been carefully planned by the A.S.M.E. staff to meet the particular requirements of A.S.M.E. members and guests. Long-standing reservations have been made for the finest services available.

The tour will include Glacier Park, Yellowstone Park, Grand Teton Park, Bryce Canyon, Zion Canyon, the North Rim of Grand Canyon, Estes Park, Rocky Mountain Park, and numerous other stops and attractions.

Write to A.S.M.E. Headquarters for complete itinerary.

Student Branch Council Plans Program

PLANS for the New England 1947 A.S.M.E. Regional Student Conference, held at Columbia University, New York, N. Y., May 10, 1947, and the implications of the E.J.C. report on "Employer Practice Regarding Engineering Graduates" were the principal topics discussed at the second meeting of the Metropolitan A.S.M.E. Student Branch Council.

The Council was created in February, 1947, to promote interchange of information on speakers and programs and to facilitate joint meetings among the student branches within the metropolitan area.

Because of limited facilities at Columbia University, attendance at the Regional Student Conference had been limited to 300 students. The task of allocating quotas to the member schools and of arranging for services during the Conferences was one of the first responsibilities assumed by the Council.

Discussion of the E.J.C. report revealed that of the colleges represented in the Council, less than one half offer formal training in human relations, which was rated high among the deficiencies noted in engineering graduates.

A. R. Mumford, vice-president A.S.M.E. Region II, and C. E. Davies, secretary A.S.M.E., complimented the Council on it initiative and participated in the discussion. Jerome Mandel, student member A.S.M.E., College of the City of New York, presided.

The following schools are represented on the council: College of the City of New York, Columbia University, The Cooper Union, New York University, Polytechnic Institute of Brooklyn, Pratt Institute, Rutgers University, and Stevens Institute of Technology.

Woman's Auxiliary Visits U. N. Headquarters

FOR its April meeting the Metropolitan Section of the Woman's Auxiliary of the A.S.M.E. sponsored a trip to the United Nations headquarters at Lake Success. This was a "repeat" by popular demand of the trip on the program of the 1946 A.S.M.E. Annual Meeting when, because of a heavy demand for reservations by out-of-town visitors, the women of the Metropolitan Section could not be accommodated.

On April 10 at 10.30 a.m. a group of 40 women left by chartered bus. They attended a session of the Security Council in the morning and heard a debate on the question of aid to Greece. This was highlighted by the speech of the United States representative, Warren Austin, and the opportunity to see at close range such international figures as Andrei A. Gromyko and Trygve Lie.

In the afternoon they visited a session of the Trusteeship Council. In the interim there was ample time to have lunch, to see the general setup of the headquarters, and to watch the people of many nationalities come and go. All in all it was one of the most interesting meetings ever planned by the Metropolitan Section.

Sections

Pittsburgh Section Holds One-Day Conference on Mechanical Engineering

Sumner B. Ely Honored by President O'Brien

YOUNG men who will graduate in the next three or four years will be the best crop of engineers to come out of the colleges in many years because they will have been "tempered by war" and because they "are conscientious, know what they want, and go after it," E. W. O'Brien, president A.S.M.E., told 250 industrialists and engineers who attended the Pittsburgh Mechanical Engineering Conference, Hotel Keystone, Pittsburgh, Pa., April 22, 1947.

The conference consisted of a program of four technical sessions and a stag banquet. It was sponsored by the A.S.M.E. Pittsburgh Section in co-operation with the Engineers Society of Western Pennsylvania, Society for the Advancement of Management, and the Material Handling Society.

President O'Brien Urges Youth Program

Speaking on "Our Interests and Their Future," President O'Brien appealed to older members of the Society to take more interest

SUMNER B. ELY RECEIVES A.S.M.E. FIFTY YEAR MEMBERSHIP BADGE FROM PRESIDENT O'BRIEN

(*Left to right:* Sumner B. Ely, Tomlinson Fort, and President O'Brien.)

in younger members and to give them an opportunity to assume responsibility in Society affairs. He told what the A.S.M.E. was doing to develop a youth program and related how some of the larger A.S.M.E. sections had appointed a junior section chairman to look after the needs of the junior members.

Referring to the unionization of engineers, President O'Brien stated that the idea of a union was incompatible with the idea of a profession. Unionization, he said, would stifle the initiative of a good engineer and reduce him to the level of a poor one. President O'Brien mentioned the recent questionnaire on labor legislation and said that the A.S.M.E. was working through the Engineers Joint Council to suggest legislation which would be acceptable to the engineering profession.

Simultaneous sessions on power-plant design and materials handling opened the conference. Eight papers were presented on such subjects as experimental steam-turbine layout, electrical devices for materials-handling equipment, new developments in electric trucks, and lightweight, heavy-duty, electric, overhead traveling cranes, and the influence of materials handling on plan-layout design.

At the afternoon sessions three papers were presented at each of two sessions on "Fuels and Lubricants" and "Better Management Through Better Managers."

Art of Burning Coal Advances

E. G. Bailey, Fellow A.S.M.E., vice-president, Babcock and Wilcox Company, New York, N. Y., in his talk on "How Best to Burn Coal in the Pittsburgh District," scoffed at the insistence on high-quality coal by users. He showed that new developments in the art of burning coal have made it possible to design equipment to burn economically solid fuel of any quality.

Alex F. Fino, student member, A.S.M.E., University of Pittsburgh, presented a paper which dealt with the methods of storage of volatile liquids at low pressure. Mr. Fino showed how "breathing" losses have been prevented by spherical storage tanks that can be placed under pressure and by liquid-sealed floating heads on cylindrical tanks.

R. J. S. Pigott, Fellow A.S.M.E., chief engineer, Gulf Research and Refining Company, Pittsburgh, Pa., spoke on "The Developments in Fuels, Lubricants, and Lubrication." Because production of 100 octane gasoline by present methods of refining would cut production to 40 or 50 per cent, and because there is no engine today that could perform satisfactorily in passenger service with compression ratios of 8.5:1 or 9:1, Mr. Pigott said that this gasoline could not be used efficiently in postwar automobiles, and that public expectation in this direction must end in disappointment.

Mr. Pigott's paper will be published in a later issue of MECHANICAL ENGINEERING. Several other papers presented at the conference are being considered for publication in one form or another.

John I. Yellott Speaks to Akron-Canton Section

On March 27 at the Women's City Club, Akron, Ohio, John I. Yellott, member A.S.M.E., director of research, Locomotive Development Committee, Baltimore, Md., addressed an audience of 30 on "The Coal-Burning Gas Turbine for Locomotive Service." The availability of various fuels for locomotive service, and basic cost per million Btu were shown, pointing to desirability of use of coal with efficient prime mover. Design problems and their solution in two experimental locomotives to be built were illustrated by slides.

J. E. FICK ADDRESSES DINNER MEETING OF A.S.M.E AKRON-CANTON SECTION

(*Left to right:* Evert George, J. E. Fick, and Myron Bowerman.)

Eighty members and 30 guests visited the plant of the Timken Roller Bearing Company, Canton, Ohio, on April 10. This inspection trip covered the Gambrinus tube mill and the Canton mill and bearing plants. A dinner was held at the Mergus Restaurant in Canton, following the trip.

Anthracite-Lehigh Valley Section Hears Talk on Labor Relations

William Naden, manager, employee-relations department, Standard Oil Company of New Jersey, was the speaker at the meeting on April 24 at the Nech Allen Hotel, Pottsville, Pa. His talk on "Labor-Management Relations" was heard by an audience of 30 members and 70 guests. Mr. Naden briefly outlined the labor policy of his company, elaborating on the points which in his estimation have made possible their 30 years of labor peace. A lively discussion following the talk attested to the interest aroused.

Jet Propulsion Talk at Baltimore Section

On March 24 at the Engineers' Club, Baltimore, Md., Reginald G. Standerwick, member A.S.M.E., chief engineer, Aircraft Gas Turbine Division, General Electric Company, spoke to 250 engineers and guests on "Jet Propulsion." The first part of the program consisted of a color movie produced by Walt Disney, entitled "Jet Propulsion." It traced the development of modern flight and included the theory and some technical data of the Army

A.S.M.E. PITTSBURGH SECTION WELCOMES PRESIDENT E. W. O'BRIEN

(*Left to right:* A. W. Robertson, E. W. O'Brien, G. H. Bucher, T. E. Purcell, C. E. Davies, and M. W. Smith.)

jets, as well as shots of the latest planes using G. E. power plants. Mr. Standerwick then described the great strides in speed the airplane has made since Glenn Curtiss' 51 mph earned him $10,000 near the end of the first decade of the century, and de Seversky's 231 mph in 1938. The speaker gave a very interesting picture of the altitude horsepower curves of the engines with no supercharging, with gear blowers, and turboblowers, from which it must be concluded that the diminutive supercharger produces 94 per cent of the power at high altitudes. Slides of the L-16 and L-180 G.E. jets were shown. A lively question-and-answer period followed the talk.

At the meeting N. E. Funk vice-president A.S.M.E. Region III, and vice-president of the Philadelphia Electric Company, spoke on the present function of the new regional organizations of the A.S.M.E., and presented to James Harry Potter of the Johns Hopkins University, a certificate of award for his work during the past years.

President O'Brien Speaks at Central Illinois Section

"Youth is an engineer's greatest asset" a group of engineering students from the University of Illinois and Bradley University were told by Eugene W. O'Brien, president A.S.M.E., in his address at the tenth annual "President's Night" banquet of the A.S.M.E. Central Illinois Section at the Peoria Country Club, Peoria, Ill., March 31, 1947. Thomas S. McEwan, vice-president, A.S.M.E. Region VI, presented certificates of award to the past-chairmen of the Section for services rendered to the Society. Awards were presented to Bentley Brown, first chairman of the Section, and to Lewis P. Weiner, Earl P. Edwards, Frank Meyers, C. G. A. Rosen, L. J. Fletcher, Wm. W. Babcock, Robert T. Mees, and Robert S. Stainton.

President O'Brien was introduced by Charles A. Davis, executive chairman, A.S.M.E. Central Illinois Section. In his address President O'Brien advised the young engineers to make the most of all opportunities and to "take an interest in your future because from now on you've got to live in it."

He said the engineering societies have accomplished much in improving and developing better engineering colleges and promoting the general standing of the profession, but that there is much room for improvement in developing and holding the interest of the young members, to give them opportunities of working in the Society's organization, to become active leaders, and to be of assistance in handling and solving civic and industrial engineering problems.

President O'Brien told of the efforts of the engineering societies to obtain favorable labor-relation laws which would give the engineers a professional consideration similar to that of the professions such as medicine and law, because of their specialized training and technical work. This type of legislation would allow the professional engineers to elect and to work out their own program as to organizing and collective bargaining if they saw fit to do so.

There were 59 members and guests in attendance, many of whom came quite a distance to hear and get the advice of President O'Brien who has been an outstanding leader in working out the problems of the engineering profession.

AT THE PRESIDENT'S NIGHT BANQUET OF THE A.S.M.E. CENTRAL ILLINOIS SECTION ON MARCH 31

(*Left to right:* G. Bentley Brown, President O'Brien, C. A. Davis, and Thomas S. McEwan.)

DURING A PLANT VISIT

(*Left to right:* President O'Brien, R. H. Walch, and C. A. Davis.)

Central Indiana Section Hears M. J. Zucrow

On April 18 an audience of 126 assembled in the Purdue Memorial Union Building, West Lafayette, Ind., to hear M. J. Zucrow speak on "Jet Propulsion." Dr. Zucrow, who is professor of gas turbines and jet propulsion at Purdue University, discussed the basic operating principles of airplane-propulsion systems, particularly thermal-jet and rocket-jet propulsion systems. Dr. Zucrow compared the different types of airplane-propulsion power plants and considered the appropriate field of application for each type.

Central Iowa Section Holds Joint Meeting

A joint meeting of the A.S.M.E. Central Iowa Section with the Iowa State College branch and the Des Moines section of A.S.M., was held on April 8 at Iowa State College, Ames, Iowa. The speaker was H. A. Highriter who gave a talk on "Powder Metallurgy." There were 200 present.

Cincinnati Section and E.S.C. Hears W. Trinks

On April 25 the Section held a joint meeting with the Engineering Society of Cleveland, Ohio, at the Schneider Memorial, Cincinnati, Ohio. Prof. Willibald Trinks, member A.S.M.E., was the speaker and his talk was entitled "Heavy Industry—The Economics of Steel Production." He first discussed the general problems of steelmaking, describing materials, methods, labor costs, and industry-wide engineering improvements made during the last 50 years. Professor Trinks illustrated and explained blast furnaces, converters, and open-hearth furnaces; also "duplexing." He explained the piercing and forging of shells and forging bomb bodies; swaging, wobbler forge, axial compression, and spinning. He answered many questions on steelmaking. Seventy-five were present.

Cleveland Section Discusses Scientific Pioneering

On April 10 at the Cleveland Engineering Society, before an audience of 100, Gordon B. Carson gave an illustrated talk entitled "Scientific Pioneering." The speaker described the application of up-to-date engineering and manufacturing practice to the old-fashioned art of making shoes.

Detroit Section Honors 15 A.S.M.E. Fellows

The annual management meeting of the Section was held in the Horace H. Rackham Memorial Building on April 1. Four hundred attended the dinner at which James W. Parker, past-president, A.S.M.E., was toastmaster, and the speaker Eugene W. O'Brien, president A.S.M.E., whose subject was "The New View-

KIM SIGLER, GOVERNOR OF MICHIGAN, WHO ADDRESSED THE A.S.M.E. DETROIT SECTION ON APRIL 1

point." President O'Brien's talk was at once a plea to the membership at large to embrace and encourage more and more activity in the Society interest on the part of the young members, and a challenge to the younger members to set their sights on the accomplishments of the 15 men who were being honored with the grade of Fellow in the Society the same evening. After dinner, 850 gathered in the main auditorium to hear the Hon. Kim Sigler, governor, State of Michigan, speak on "The Foundation of Good Government." His honor, the Governor, pointed out that the foundation of good government originated in the individual, and that history bears out that good government must be directed back to the individual's best interest. Those residents of Michigan who heard Governor Sigler for the first time were deeply impressed with his philosophy and his personality. President O'Brien presented Fellow-grade certificates to the following members of the Detroit Section: Carl Breer, George C. Daniels, Henry B. Dirks, Horace H. Esselstyn, Henry Ford, K. T. Keller, Charles F. Kettering, Charles S. Mott, James W. Parker, Paul W. Thompson, Jesse G. Vincent, Albert E. White, George B. Willcox, Harry T. Woolson, and Fred M. Zeder. Guests included the student branches of the University of Detroit, University of Michigan, and Michigan State College.

Otto de Lorenzi Speaks at East Tennessee Section

The regular monthly dinner meeting of the Chattanooga Group of the East Tennessee Section was held on April 11 at the Chattanooga Golf and Country Club, Chattanooga, Tenn., and was attended by 110 members and guests. The speaker was Otto de Lorenzi, director of education, Combustion Engineering Company, Inc., New York, N. Y., who gave a talk on "Burning of Pulverized Fuel," which was illustrated with Kodacrome motion pictures. A portion of the picture was shown in ultraslow motion. Mr. de Lorenzi said that the use of motion pictures to record furnace conditions in steam-generating units provides the combustion engineer with a valuable research tool. Through the use of the pictures it is possible to study the succession of events which occur during the entire combustion process. The photographic technique employed must be well adapted to the type of action it is desired to portray. With stoker fuel beds, which move at an extremely slow rate, the time-lapse system is used whereby individual pictures are taken at predetermined time intervals and then projected at normal rates to speed up the fuel bed without actually changing normal operation. For the study of flame propagation or gas flow, it is necessary to slow down the action if an accurate analysis is to be made. This is accomplished by using semislow or ultraslow motion. With this method the film passes through the camera at a predetermined high rate and is then projected at normal speed to reveal many interesting factors that have an important bearing on furnace performance. Further, the speaker said, successful pulverized-fuel firing depends on a uniform distribution of fuel and air across the furnace width to insure prompt ignition and completion of the combustion process, before the heating surfaces of the boiler are reached.

Kansas City Section Holds Dinner Meeting

The April meeting was a dinner meeting at the University Club, Kansas City, Mo., attended by approximately 65 members. Papers were presented by Mr. Hobbs, University of Kansas, and Mr. Coulson, Kansas State College. These men were winners of the student competition sponsored by the Section. Mr. Hobbs's paper dealt with gas turbines and Mr. Coulson's with aircraft-landing systems. Other winners in the competition were Mr. Hadley of Kansas University and Mr. Hedrick of Kansas State College.

Personal Flying Subject at New Haven Section

On March 9 a dinner meeting was held at Ceriani's Cafe Mellone, New Haven, Conn. Following the dinner, the 35 members went to the United Illuminating Company's auditorium to hear C. A. Moeller, II, who spoke on "Personal Flying." Mr. Moeller, who was engineering test pilot for Sikorsky Aircraft, described the development of the Sikorsky helicopter and the technical development, and answered questions regarding design and construction. His talk was accompanied by a sound motion picture in color.

North Texas Section Judges Papers by S.M.U. Students

On March 21 at the D.P.&L. Company Building, Dallas, Tex., four members of the A.S.M.E. Southern Methodist University, Student Branch presented papers to determine S.M.U. representation at the student meeting, University of Oklahoma. First place went to Cecil Dotson for his paper on "Job Evaluation." Second place was awarded to Clarence Eaton for "Peak Day-Load Analysis of Lone Star Gas Systems," and Frank McGowan and Dick Turner tied for third place. Twenty-eight were present.

Symposium on New Uses of Oxygen at Pittsburgh Section

On March 25 at the William Penn Hotel, Pittsburgh, Pa., more than 200 engineers heard L. L. Newman, Bureau of Mines, Washington, D. C., discuss the critical role that oxygen plays in coal gasification. Mr. Newman described the various methods which have been tried in the United States and abroad for the gasification of coal, and showed that almost invariably the factor limiting production has been the oxygen supply. Speaking at the same meeting, which was a symposium on "New Industrial Uses of Oxygen," C. R. Downs, Member A.S.M.E., consulting chemist, New York, N. Y., stated that recent developments in oxygen production have greatly lowered the cost, so that use of oxygen on a large scale is now economically feasible. J. H. Rushton, Illinois Institute of Technology, Chicago, Ill., described some of the processes under consideration for the production of low-cost oxygen. The role of oxygen in boosting production in the steel industry was discussed by Walter N. Flanagan, member A.S.M.E., Carnegie-Illinois Steel Corporation, Pittsburgh, Pa. Mr. Flanagan made it clear that there are tremendous potential uses for oxygen in steel mills, such as for blast furnaces, open hearths, and Bessemer converters, but that the extentand rapidity of developments in this field will depend on how well the initial and operating costs balance the greatly increased production. Tomlinson Fort, chairman of the Section, presided.

Westmoreland Committee Holds Dinner Meeting

On March 18 a dinner meeting was held by the Westmoreland Committee of the A.S.M.E. Pittsburgh Section at the Mountain View Hotel, near Greensburg, Va. A nominating committee was named for proposing a list of officers to be elected for the coming year's service. There were two speakers on the program; the first, John Ponkow, sales manager, welder division, Federal Machine and Welder Company, Warren, Ohio, who gave an illustrated talk on "Application of Resistance Welding in Industry." The second speaker, William M. Roggerson of the Aluminum Company of America, gave an illustrated talk on "How to Weld Aluminum." J. F. Cunningham, Jr., led the discussion following the two talks.

Providence Section Visits Gorham Manufacturing Company Plant

On April 1 an inspection trip was made to the plant of the Gorham Manufacturing Company, Providence, R. I. Elliott M. Gordon, executive vice-president of the company, spoke to the visitors at a reception held in the office building. He described the manufacture of silver flat and hollow ware, and casting of bronze statues. Fourteen enjoyed the program.

Raleigh and Piedmont Sections Hold Joint Meeting

The Raleigh Section joined with the Piedmont Section in a joint meeting on April 25 to which the student members of the A.S.M.E. branches of Duke University and North Carolina State College were invited. Members and students met at the new Strickland streamlined furniture plant and were shown the general layout and construction, although the plant is not yet in production. A visit was made to Tomlinson's of High Point, furniture plant, where A. W. Dunbar, one of the High Point members, and chief engineer of Tomlinson's, escorted the visitors through this up-to-date furniture plant. Next was visited the new Gibson ice-cream plant, one

of the latest and most modern plants for the making of ice cream in the Southeastern U. S. Mr. Gibson and his corps of technicians conducted the several parties through the establishment.

Dinner was served in the Sheraton Hotel ballroom to 80 persons. The speaker was Ernest J. Abbott, member A.S.M.E; president and general manager, Physicists Research Company, Ann Arbor, Mich., who gave a talk on "Profilometer Readings on Surface Roughness in Small Manufacture." Mr. Abbott explained the use of the profilometer in controlling the surface roughness. With slides and samples he showed its value to industry, and described its manufacture and use during the war. He said that few people understood roughness until a few years ago when the need for greater precision became apparent for more delicate machinery. It came as a result of the demand for precision machines.

Glass in Industry Discussed at Rock River Valley Section

A joint meeting with the Technical Club of Madison, Wis., and the A.I.E.E. Section was held on April 7 in the Presbyterian Church, Madison, Wis. E. M. Guyer of the Corning Glass Works, Corning, N. Y., gave a talk entitled "The Story of Glass—New Advances in an Old Industry." Dr. Guyer discussed problems arising from the use of glass for insulation and as a dielectric in high-frequency electronic devices. He showed how the use of high-frequency heating and electrical welding was extending the use of glass in industry. The talk was illustrated with slides and exhibits. An audience of 207 listened with interest to Dr. Guyer.

San Francisco Section Inspects Cyclotron

On March 27 approximately 150 members and 150 guests visited the Radiation Laboratory, University of California, Berkeley, Calif., to inspect the 184-in. cyclotron. This cyclotron was made intelligible to mechanical engineers by members of the laboratory stationed at strategic points, and their lucid explanations, coupled with the opportunity to observe the equipment, made the trip one of educational value. On the same day, at the Berkeley Women's City Club, the members and guests heard W. M. Brobeck, assistant director of the Radiation Laboratory, speak on the "Design and Construction of the Cyclotron." He explained briefly the operating principles and traced the history of cyclotrons at the University. He also indicated the design changes that accompanied increased knowledge of nuclear physics. His talk was illustrated with slides. Dr. W. M. Powell, associate professor of physics at the University, and physicist of the Radiation Laboratory, spoke on "Applications of the Cyclotron." He impressed the audience with the enormous energies involved in atom-smashing. He said that the relatively low energy levels attainable with existing equipment, while adequate for current studies, limit the research that can be conducted in the field of nuclear physics. Numerous "cloud" pictures of the disintegration of atoms upon bombardment with neutrons were shown.

W. Julian King Speaks at Southern Tier Section

The tenth-anniversary dinner meeting of the Section was held at the Hotel Frederick, Endicott, N.Y., on April 28. W. Julian King, member A.S.M.E., director Sibley School of Mechanical Engineering, Cornell University, was the speaker. In his talk Mr. King said that a successful engineering career can be determined in advance by suitable planning, assuming normal raw material, by observing the necessary rules and procedures. He further said that success in engineering is a marginal matter but it need not be left to chance. He recommended a well-rounded normal life, an education in a recognized college, and an initial experience-providing period of three to five years with some large industrial firm. He warned against setting too low a goal or standard in any endeavor, and advised a study of people and an investment of time and work in community projects. Forty members and guests were present.

Four Meetings Held by Southern California Section

On April 7 in the Rodger Young Auditorium, Los Angeles, Calif., Perley C. Hamlin, industrial engineer, National Supply Company, spoke on "The Application of Incentive Wage-Payment Plans." After analyzing the various types of incentive-wage payment plans, the speaker listed the advantages and disadvantages, specific applications, etc. A forum discussion followed, with 28 members and 3 guests of the audience of 66 participating.

A second meeting was held in the Rodger Young Auditorium on April 17, with 49 present. Dr. O. Rosenthal, University of California at Los Angeles, Calif., gave a talk entitled "Brittle Failure of Welded Structures." He discussed the failure of the first all-welded steel bridge, 250-ft span which was erected in Belgium and which failed in 1938. This failure was then compared with the experience of U. S. ships of welded construction "breaking in two." Commander Killian, U.S.N., who was assigned to investigate these failures, was present and spoke on specific problems.

On April 23 at the California Institute of Technology, Pasadena, Calif., an engineering student competition was held for members of student branches. William J. Walker, student at University of Southern California, won the first prize of $50 for his paper, "Ceramic

AT THE TENTH ANNIVERSARY DINNER OF THE A.S.M.E. SOUTHERN TIER SECTION ON APRIL 28
(*Left to right:* H. H. Mabie, Walter G. Baird, W. Julian King, Fred S. Erdman, H. C. Perkins, and Raymond W. Ramage.)

Materials for Use as Turbine Blades." The second prize of $25 was won by Edwin A. Pecker, University of California at Los Angeles, Calif., for his paper on "Plywood in the Aircraft Industry." R. W. Poindexter won the third prize of $10 for his paper "Design and Construction of Airplane Wind-Tunnel Models." Sixty-seven were present.

E. P. McEltish was the speaker at the meeting on April 24 held in the auditorium of the Southern California Gas Company, Los Angeles, Calif. In his talk on "Metallurgy in Oil Refining," he stressed the importance of research in order to specify proper specifications of alloy steel for oil-refinery projects, both from the performance and cost standpoint. One hundred and forty-seven were present.

Two Speakers at Syracuse Section

At the Syracuse Technology Club, Syracuse, N. Y., on April 16, talks on "Centrifugal Pumps" were given by A. G. Forssell and G. J. Gruber of the Morris Machine Works. Mr. Gruber discussed the theory and practical design features of centrifugal pumps and Mr. Forssell covered problems in their application. The meeting was then opened for questions and many members participated in a lively discussion.

Toledo Section Has Joint Meeting With A.I.E.E.

The Section held a meeting with the A.I.E.E. on March 20 in room 101, University of Toledo, Toledo, Ohio. The program, arranged by the A.I.E.E., consisted of talks by T. Caldwell, Jr., and D. H. Gilmore, of the magnesium division, Dow Chemical Company, Cleveland, Ohio. The subject covered was "Refining and Use of Magnesium." The history of the magnesium industry was covered from its astounding growth from about five million pounds per year in 1938 to five hundred million pounds per year during the recent war. Following the talks, a film entitled "Working of Magnesium" was shown, through the courtesy of the Dow Chemical Company. This covered all means of handling and forming, machining, etc., of magnesium.

Virginia Section Holds Joint Meeting

On April 25 at the Richmond Hotel, Richmond, Va., 175 members of the Section and of Central Virginia Engineers Club heard John I. Yellott, member A.S.M.E., director of research, Locomotive Development Committee, Baltimore, Md. Mr. Yellott said that the coal-fired gas-turbine locomotive pilot plant is working satisfactorily and demonstrating the feasibility of burning pulverized coal. The pilot plant is located at the Dunkirk, N. Y., works of the American Locomotive Company. Details of its operation were described by the speaker, who said that the coal-fired gas turbine also has a great potentiality for stationary and marine power purposes. He declared that the gas turbine is a "natural" for railroad locomotives because of its compactness and small size per horsepower.

Talk on Color Conditioning in Industry Heard by Waterbury Section

On March 26 at the Chase Country Club, Waterbury, Conn., an audience of 30 heard L. E. Whitmoyer, sales technical adviser, E. I. du Pont de Nemours Company, Inc., Philadelphia, Pa., speak on "Color Conditioning in Industry." Mr. Whitmoyer showed movies demonstrating what had been done in industry by color-conditioning interiors and machines. Following the movies, he gave a talk on the choice of colors and why they were used in different places. An interesting question period followed in which specific applications were discussed.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3.50 per quarter or $12 per annum, payable in advance.

New York	Chicago	Detroit	San Francisco
8 West 40th St.	211 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

MECHANICAL AND INDUSTRIAL ENGINEER, excellent record, fifteen years as plant engineer, plant superintendent, and master mechanic. Age 38. Tool and die-making background. Thorough knowledge of wage-incentive plans. Ability to get along well with men. Me-178.

INDUSTRIAL ENGINEER, especially qualified by education and experience to supervise cost, production, and budgetary-control systems, together with wage-administration program. Seeks connection with progressive organization. Me-179.

EXECUTIVE MECHANICAL ENGINEER, with well-rounded experience in maintenance, production, cost control, and management particularly in foundries or light manufacturing. Peculiarly equipped to assist in casting design and purchasing. Me-180.

MECHANICAL ENGINEER, graduate, age 24. Three years' diversified experience in plant layout, machine-shop methods, mechanical design, and development. Desires position in industrial or development-engineering department of large concern. Me-181.

MECHANICAL ENGINEER, graduate, veteran, age 30. Ten years' varied experience as manufacturer of electromechanical instruments, Army ordnance production engineer, manufacturing-engineering supervisor, assistant production manager, designer-draftsman and materials-laboratory aid. Me-182.

EXECUTIVE ENGINEER, B.S. in E.E., 19 years' experience communications, heavy-machine manufacture, deep-drawing of brass and steel; tool-die and machine design; chief engineer; production manager factory of 500 employees. Age 41, single. Desires managerial or chief engineer's position. Me-183.

GRADUATE ENGINEER, B.S.M.E. New York University. Mechanical and industrial options, one year diversified experience, desires contact with organization where good services will provide for a future. Age 21. Me-184.

MECHANICAL ENGINEER, 33, single, B.S.M.E. Two years' industrial experience in production department of large company. Chief interest is quality control through statistical methods. Have picked up "know how" on forgings, machining, heat-treating, and grinding. Will be an asset to any metals manufacturer especially in the like processing. Only restriction, location. Preferred East. Me-185.

MECHANICAL ENGINEERING GRADUATE, 27, single, experienced in plant layout, materials handling, cost analysis, and fuel conversion. Has drive and determination. Seeking job with good future. Me-186.

INDUSTRIAL ENGINEER, 28, single, B.S. and 2 master degrees (mechanical and administrative). Diversified experience. Desires permanent position with manufacturing concern. Prefer production control, methods, motion study, but will consider other work. Moderate salary requirements. Me-187.

POSITIONS AVAILABLE

MECHANICAL ENGINEER with experience in

[1]All men listed hold some form of A.S.M.E. membership.

steam-power plants, installing and maintaining boiler auxiliaries. Design experience on valves and instruments required. Working knowledge of thermodynamics essential. Southeastern Pennsylvania. W-8615.

MECHANICAL ENGINEER, 35–45, capable of assuming post of chief engineer for power-transmission-equipment manufacturer. Should be skilled in design, inclined toward research, and with some administrative experience. Salary commensurate with experience and ability. Pennsylvania. W-8751.

MECHANICAL ENGINEER, about 33–38, for design and development of processes and machines for printing concern. Experience in textiles or graphic arts and an understanding of handling of paper inks desirable. Some traveling. Delaware. W-8940.

STREET RAILWAY TRANSPORTATION ENGINEER, 30–40, mechanical or electrical graduate, with some specialization in street-railway and bus transportation as to economic and operating phases and several years' experience in contact with operating and/or regulatory problems of street transportation companies. Should have some acquaintance among management personnel in this line. Write giving education and experience. $6000, New York, N. Y. W-8946.

ASSISTANT PROFESSOR AND INSTRUCTORS for mechanics department. Rank and salary depending upon qualifications. Opportunity for advanced courses. Upstate New York. W-8949.

MECHANICAL ENGINEER experienced in designing boilers with particular reference to welded construction and capable of assuming full responsibility for manufacturing process of high-pressure steam-generating units and boilers. Pennsylvania. W-8959.

ENGINEERS AND LAYOUT DRAFTSMAN, graduates, 25–35, with some experience in design of farm or similar machinery, to work on design and development of farm machinery. $2500–$4000. Pennsylvania. W-8961.

ASSISTANT CHIEF ENGINEER, 35–40, mechanical graduate, with textile-machine design, plant-maintenance and mill-construction experience, to take charge of general-plant-engineering department. Some traveling. Must have engineering license, preferably New York. $7000–$8000. New York, N. Y. W-8964.

PRODUCTION DESIGN ENGINEER, 40–50 preferred, mechanical or electrical graduate with thorough experience in the design and development of small precision products which involve electrical and mechanical application. Must be able to handle all the engineering problems from design to the finished product. Salary open. Upstate New York. W-8971.

GENERAL MANAGER who is a good business executive and capable of building a sales organization and getting results for manufacturer of woodworking tools used in lumberyards and by building contractors. Company employs about 70 employees mostly machinists and machine operators. Must have technical and cost experience to direct the internal organization effectively and direct an engineering group in development and expansion of above products. New England. W-8976.

PROJECT ENGINEER, mechanical graduate, with 10 to 12 years' progressive diversified experience in the development of new process equipment. Will be responsible for the development of new ideas through to the complete manufacture of equipment. $7500–$8500. Pennsylvania. W-8979.

ENGINEER, graduate, with sound engineering ability in refrigeration, preferably familiar with Frigidaire refrigeration and air conditioning and Delco heating-equipment installation, to make estimates, supervise installation and service departments. Salary, $5000 year plus bonus. Connecticut. W-8996.

ENGINEERS. (a) Methods engineer, senior, mechanical graduate or equivalent, with 10 years' experience as methods engineer or similar position in the manufacturing of small precision parts from round and flat stock, and capable of designing tools, dies, jigs, fixtures, etc. $4200–$4560. (b) Methods engineer, junior, mechanical graduate or equivalent, with training or experience as methods engineer or minimum of five years' shop experience in manufacture of small parts. $3900–$4200. (c) Systems engineer with three to five years' experience in business control and procedure in the manufacturing industry, preferably of small parts. Must have thorough knowledge of paper work in office procedure. $3900–$4200. Write giving full details and business references. California. W-9000.

RESEARCH ENGINEER with paperboard-technology experience, to take charge of research program covering all aspects of corrugated-fiber-shipping containers. $8000–$10,000. New York, N. Y. W-9007.

ENGINEERS. (a) Project engineer, 35–45, with responsible experience in machine design and knowledge of various processes of steel. Will be required to co-ordinate all engineering and shop practices. $6000–$7500. (b) Process engineer, 35–45, with considerable experience in metal shop, layout of plant, and various processes involving plate steel. $6000. Ohio. W-9011.

CHIEF ENGINEER with minimum of 10 years' experience in design, research, and development of steam-generating equipment. Will be required to co-ordinate the above with production and sales departments. $10,000. Pennsylvania. W-9012.

TEACHING PERSONNEL, mechanical graduates. (a) Associate professor to teach thermodynamics, heat power. M.S. degree with industrial experience desirable. (b) Assistant professors, 2; one majoring in heat power and the other in theoretical mechanics and design. (c) Instructors for classroom and/or laboratory. (d) Instructors of engineering drawing. Salaries commensurate with training and experience. North Dakota. W-9047.

ASSOCIATE PROFESSOR to direct the teaching of internal-combustion-engine theory and laboratory work. Preferably should have a master's degree in mechanical engineering, with some teaching experience and some research and testing experience in this field. Work will start in Sept., 1947. Chicago, Ill. $4500 for nine months' work. R-4044-C.

TEACHING PERSONNEL. (a) Teacher of machine-shop work beginning in Sept., 1947, for a state university with facilities at the Navy Pier, Chicago, Ill., which they expect to make permanent. (b) Teacher of theoretical mechanics, statics, dynamics, and strength of materials. $300–$400 a month. Starts September, 1947. Illinois R-4156-C.

MECHANICAL ENGINEERS, recent graduates for design and production of motors and generators. Wisconsin. $225 a month. With some experience $250. R-4162-C.

TEACHING PERSONNEL. Teachers in physics, contract to begin on Sept. 1, 1947, and teaching to start on Sept. 15, 1947, for a state university with facilities at the Navy Pier, Chicago, Ill., which they expect to make permanent. $300–$400 a month, depending on ability and experience. Illinois R-4165-C.

ENGINEERING TEACHERS, civil, electrical, and mechanical engineers in new engineering department of a California state college. Teaching, laboratory layout, and equipment selection. No research. At least 1 year of graduate study required. Instructors $2820–$3270; assistant professors $3240–$3960; associate professors $3780–$4440. Nine-month year, starting Sept. 29, 1947. Apply by letter. California. S-686.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after June 25, 1947, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Fellow, Member, Associate, or Junior

AHLBERG, AXEL H., Sunnyvale, Calif.
AUSTIN, JACKSON K., St. Louis, Mo.
BANTON, HARTLEY L., Newport, Me.
BARNABY, GLENN C., San Francisco, Calif (Rt)
BEEMAN, DONALD R., Wharton, N. J.
BENSON, EARLE G., Chicago, Ill.
BENTLEY, THOMAS ROSS, SR., Long Island City, N. Y.
BREWTON, CLARENCE W., Dallas, Texas
BROCK, FRANK E., Minneapolis, Minn.
BRYAN, ROLAND T., Alliance, Ohio.
BURGESS, NORMAN O., Montgomery, W. Va. (Rt & T)
BURNHAM, ROBERT S., Stoughton, Mass.
CANVASSER, GEORGE, Detroit, Mich.

CARBONELL, JUAN A., Santurce, P. R.
CARDWELL, PAUL H., Tulsa, Okla.
CARSON, WILLIAM JOHN, West Hartford, Conn.
COCHRANE, GORDON S., Lynnfield Center, Mass.
COREY, RICHARD C., Pittsburgh, Pa.
CREESE, JAMES, Philadelphia, Pa.
CROMWELL, C. E., Detroit, Mich. (Rt)
CRUM, E. M., South Charleston, W. Va.
CUNNINGHAM, L. V., JR., Chicago, Ill.
DEATHERAGE, GEORGE E., Baltimore, Md. (Rt)
DEVOSS, CHARLES R., Mishawaka, Ind.
DROEL, LOUIS W., Rochester, N. Y.
DU BOIS, ARMAND S., New York, N. Y.
DURYEE, ANDREW B., New Rochelle, N. Y. (Rt)
EASTIN, MAURICE R., New York, N. Y.
ENNIS, JOHN F., Brooklyn, N. Y.
FALKE, CLEAL, San Antonio, Texas
FARLOW, CARL P., JR., Birmingham, Ala.
FEDDEN, A. H. ROY, SR., London, England.
GARDINER, ELLIOTT W., Conklin, N. Y.
GARRETT, G. C., Akron, Ohio
GARRETT, ROBERT M., Los Alamos, N. M.
GIEROW, PAR, Nol., Sweden
GRANDIA, W. M., York, Pa.
GUTLEBEN, DAN, San Francisco, Calif.
HANSTEIN, WALTER, Atlantic City, N. J.
HARGROVE, F. L., Schenectady, N. Y.
HARRIS, WALTER C., Erie, Pa.
HASTINGS, WARD E., Chattanooga, Tenn.
HOLBROOK, FORREST C., Los Angeles, Calif.
HUETER, J. B., Hampton, Va.
HUJA, J. S., Bannu, India
HUNT, STANLEY P., Charlottesville, Va.
HURST, RUSSEL F., Great Neck, N. Y.
HUTCHINSON, ROBERT M., Havertown, Pa.
JULKOWSKI, ANTHONY J., Minneapolis, Minn.
KENDALL, JULIUS, Garden City, N. Y.
KUCEJ, ING. L., Shanghai, China
LANGO, CHARLES H., Ypsilanti, Mich.
LAWRENCE, THEODORE G., Hermosa Beach, Calif.
LEWIS, JOSEPH C., Fort Wayne, Ind.
LINDLEY, L. ELDON, JR., Media, Pa.
LINN, M. H., Rock Island, Ill.
LITTLEJOHN, SAM, Cynwyd, Pa.
MAKAROFF, CYRIL E., Berkeley, Calif.
MALILA, JITTI V., Washington, D. C.
MASON, J. W., Houston, Texas (Rt)
MASSON, DAVID JENKS, Maplewood, N. J.
MCCLEAN, H. G., LaGrange, Ill.
MCCLELLAN, STEPHEN A., Glen Cove, N. Y.
MCDERMOTT, JOHN F., Manchester, Conn.
MEYERS, JOHN C., JR., Baldwinsville, N. Y.
MIDDLETON, H., Broken Hill, Australia
NOREN, DELBERT P., Chicago, Ill.
OAKES, EDWARD J., New Orleans, La.
OLANDER, ROLAND J., Chicago, Ill.
PIERCE, RICHARD V., North Hills, Pa.
PURDY, C. C., Lachine, Quebec, Can.
RAMACHANDRAN, A., West Lafayette, Ind.
RANKIN, KENNETH S., Barberton, Ohio
REAM, CHARLES E., Fort Wayne, Ind.
REES, OWEN, San Luis Obispo, Calif.
ROUX, DALE J., Perrysburg, Ohio
RUBIN, SAUL, Cleveland Heights, Ohio
RYLANDER, H. G., JR., Prospect Park, Pa.
SCHAEFER, CLAUDE W., Baltimore, Md.
SCHLESINGER, S. PERRY, Schenectady, N. Y.
SCHMITT, LAWRENCE B., Park Ridge, Ill.
SCHULZ, ERICH H., Hamburg-Klein Flottbek, Germany
SHANKS, GORDON L., Park Ridge, Ill. (Rt)
SIMPELAAR, CLYDE, Racine, Wis.
SMALL, RAY A., Marietta, Ga.
SPENCER, EDWARD M., Ferndale, Mich.
SPRIEGEL, WILLIAM R., Evanston, Ill.
STERN, E. GEORGE, Blacksburg, Va.
STROMBACK, DURAY E., Philadelphia, Pa.
SUBRAMANYAM, B. R., Bangalore, India
THOMAS, D. RANDOLPH, Jackson Heights, N. Y.
TYGART, JESSE L., Toledo, Ohio (Rt)
UHLER, WILLIAM P., New York, N. Y.
VAN DYKE, B. H., Greensburg, Pa.
VEDAMANIKAM, F. J., Washington, D. C.
VEDANTH, T. C., Lahore, India
VICHICH, FRED L., Endicott, N. Y.
WAGNER, ERNEST A., Stratford, Conn.
WANZER, C. T., Charlotte, N. C.
WATTENDORF, FRANK L., Dayton, Ohio
WEBER, JOHN P., Brooklyn, N. Y.
WEIDNER, W. E., Chattanooga, Tenn.
WHIPPLE, J. VAN H., New York, N. Y. (Rt)
WRIGHT, CLARENCE J., St. Louis, Mo.
ZAWADOWICZ, STANISLAUS J., Jersey City, N. J.
ZWEIFEL, ROY H., Milwaukee, Wis.

CHANGE IN GRADING

Transfers to Fellow

ROSEN, C. G. A., Peoria, Ill.

Transfers to Member

BEEMER, PAUL K., Inglewood, Calif.
BLOSE, JAMES F., Annapolis, Md.
BOARD, SAMUEL S., JR., Ansonia, Conn.
BROWN, GRAHAM B., Youngstown, Ohio
CLARK, ELLERY D., Beverly, Mass.
DECKER, H. L., Ardmore, Pa.
GILBERT, R. L., London, Ontario, Can.
HARRIS, HAROLD C., Hatboro, Pa.
HENDERSON, GEORGE A., Nashville, Tenn.
HESTAND, RUE S., Fort Worth, Texas
HYDE, HARLAN W., Baltimore, Md.
KNAPP, ROBERT T., Pasadena, Calif.
PAGE, RAYMOND L., South Pasadena, Calif.
ROBINSON, EMERSON J., Milford, Mass.
ROBINSON, HAROLD I., Philadelphia, Pa.
SCHICKEDANZ, L. H., Canton, Ill.
SMITH, PRESCOTT A., Cambridge, Mass.
SMITH, WILLIAM HENRY, Peoria, Ill.
WAGNER, WARREN O., Pasadena, Calif.
WOGNUM, JAMES N., Chicago, Ill.

Transfers from Student Member to Junior....130

Necrology

THE deaths of the following members have recently been reported to headquarters:

BEACH, CHARLES S., March 19, 1947
BERNHARD, RICHARD, February 2, 1947
BISSELL, GEORGE W., January 24, 1947
BONNELL, JOHN R., March 25, 1947
BROOKS, MORGAN, April 23, 1947
CANNON, ARTHUR H., April 16, 1947
CHAMBERLAIN, WILLIAM T., April 9, 1947
COLLINS, JOHN A., March 16, 1947
GABRIEL, WILLIAM A., March 23, 1947
GRAY, ELLSWORTH S., April 11, 1947
HELWIG, ALFRED, April 21, 1947
KUYLENSTJERNA, ADOLF L., March 16, 1947
MORTON, ARTHUR B., February 18, 1947
NORRIS, CHARLES H., December 18, 1946
WADSWORTH, JOHN F., November 19, 1946
WATERFALL, HARRY W., March 26, 1947
WILLIAMS, HOWARD E., October 28, 1946
WILSON, HENRY D., April 1, 1947

Five-Day Standardization Seminar Planned

AN intensive five-day seminar on the organization and technique of industrial standardization will be made available to company-standards engineers, educators planning a college-instruction course in standardization, and others, by Dr. John Gaillard, engineer for A.S.A., at the Engineering Societies Building, 29 West 39th St., New York, N. Y., during the week of June 23–27, 1947.

For further information, write to Dr. John Gaillard, 400 West 118 St., New York 27, N. Y.

A.S.M.E. Transactions for May, 1947

THE May, 1947, issue of Transactions of the A.S.M.E. contains the following papers:

The Hardened and Tempered Microstructure of High-Speed Tool Steel as a Factor in Tool Performance, by W. H. Wooding

X-Ray Diffraction as a Gage for Measuring Cold Work Produced in Milling, by F. Zankl, A. G. Barkow, and A. O. Schmidt

Tracer-Point Sharpness as Affecting Roughness Measurements, by D. E. Williamson

Surface Finish of Steel in Face-Milling, by A. O. Schmidt

Regulation Theory for Thermal Power Plants Employing a Closed Gas Cycle, by F. Salzmann

Unfired Cylindrical Vessels Subjected to External Pressure, by F. V. Hartman

Master Charts for the Design of Vessels Under External Pressure, by D. F. Windenburg

Computing Strength of Vessels Subjected to External Pressure, by R. G. Sturm and H. L. O'Brien

Measurement of the Viscosity and Shear Elasticity of Liquids by Means of a Torsionally Vibrating Crystal, by W. P. Mason

Performance of Vertical Water Wheel Thrust Bearings During the Starting Period, by C. M. Laffoon, R. A. Baudry, and P. R. Heller

An Analysis of the Parallel-Surface Thrust Bearing, by M. C. Shaw

Corrosion-Erosion of Boiler Feed Pumps and Regulating Valves, by H. A. Wagner, J. M. Decker, and J. C. Marsh

Investigation of Acid Attack on Boilers and the Effect of Repeated Acid Cleaning on the Metal, by H. C. Farmer

Three Systems for Handling and Storing Metal Chips, by S. Reibel

The Coefficients of Thermal Expansion of Wood and Wood Products, by R. C. Weatherwax and A. J. Stamm

Part-Load Characteristics of Marine Gas-Turbine Plants, by W. M. Rohsenow and J. P. Hunsaker